EXHIBIT 13

21-2249, 21-2315

UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

CARNEGIE INSTITUTION OF WASHINGTON, M7D CORPORATION,
Plaintiffs-Appellants,

v.

FENIX DIAMONDS LLC,
Defendant-Cross-Appellant

Appeals from the United States District Court for the Southern District of New York in No. 2:20-cv-00200-JSR, Judge Jed S. Rakoff.

CONFIDENTIAL OPENING BRIEF OF APPELLANTS CARNEGIE INSTITUTION OF WASHINGTON AND M7D CORPORATION

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July 6, 2022

REPRESENTATIVE CLAIM

1. A method for diamond production, comprising:

controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C.; and

growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr.

Appx102-103.

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

CERTIFICATE OF INTEREST

Case Number 21-2249, 21-2315

Short Case Caption Carnegie Institution of Washington v. Fenix Diamonds LLC

Filing Party/Entity Carnegie Institution of Washington and M7D Corporation

Instructions: Complete each section of the form. In answering items 2 and 3, be specific as to which represented entities the answers apply; lack of specificity mayresult in non-compliance. **Please enter only one item per box; attach additional pages as needed and check the relevant box**. Counsel must immediately file an amended Certificate of Interest if information changes. Fed. Cir. R. 47.4(b).

I certify the following information and any attached sheets are accurate and complete to the best of my knowledge.

Date: 7/6/2022

Signature: /s/Nathan K. Kelley

Name: Nathan K. Kelley

1. Represented Entities. Fed. Cir. R. 47.4(a)(1).	**2. Real Party in Interest.** Fed. Cir. R. 47.4(a)(2).	**3. Parent Corporations and Stockholders.** Fed. Cir. R. 47.4(a)(3).
Provide the full names of all entities represented by undersigned counsel in this case.	Provide the full names of all real parties in interest for the entities. Do not list the real parties if they are the same as the entities. ☑ None/Not Applicable	Provide the full names of all parent corporations for the entities and all publicly held companies that own 10% or more stock in the entities. ☐ None/Not Applicable
Carnegie Institution of Washington		None
M7D Corporation		WD Diamonds Holdings, LLC

☐ Additional pages attached

4. Legal Representatives. List all law firms, partners, and associates that (a) appeared for the entities in the originating court or agency or (b) are expected to appear in this court for the entities. Do not include those who have already entered an appearance in this court. Fed. Cir. R. 47.4(a)(4).

☐ None/Not Applicable ☐ Additional pages attached

Perkins Coie LLP	Terrence J. Wikberg	Amy Simpson
Sarah E. Fowler	Michelle M. (Umberger) Kemp	Kevin Patariu

5. Related Cases. Provide the case titles and numbers of any case known to be pending in this court or any other court or agency that will directly affect or be directly affected by this court's decision in the pending appeal. Do not include the originating case number(s) for this case. Fed. Cir. R. 47.4(a)(5). See also Fed. Cir. R. 47.5(b).

☑ None/Not Applicable ☐ Additional pages attached

6. Organizational Victims and Bankruptcy Cases. Provide any information required under Fed. R. App. P. 26.1(b) (organizational victims in criminal cases) and 26.1(c) (bankruptcy case debtors and trustees). Fed. Cir. R. 47.4(a)(6).

☑ None/Not Applicable ☐ Additional pages attached

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TABLE OF AUTHORITIES

Cases **Pages**

Statutes

TABLE OF ABBREVIATIONS AND CONVENTIONS

Carnegie	Appellants Carnegie Institution of Washington and M7D Corporation
Fenix	Cross-Appellant Fenix Diamonds LLC
xx:*yy-zz*	column *xx*, lines *yy-zz* of a patent
’078 patent	U.S. Patent No. 6,858,078

Statement of Related Cases

No other appeals regarding this district court case or the patent at issue in this appeal (U.S. Patent No. 6,858,078) have been before this or any other appellate court.

Counsel for appellants Carnegie Institution of Washington and M7D Corporation are not aware of any other case that will directly affect or be directly affected by this Court's decision in this appeal.

INTRODUCTION

This fact-specific dispute was decided prematurely based on a flawed claim construction, an improper inference made against Carnegie, and a failure to even acknowledge Carnegie's evidence of Fenix's infringement.

Carnegie patented a process for growing gemstone quality diamonds at greater speeds than previously possible. Manufactured diamonds are grown under high pressure and temperature using a deposition process in which carbon atoms attach to the growth surface of an existing diamond "seed." A "perfect" diamond—were one to exist—is a single crystal, with each carbon atom correctly aligned in the crystal lattice structure. But no diamond is truly perfect. Flaws are inevitable, both in nature and in science. Gemstone quality diamonds differ from those used in industry because they are substantially monocrystalline except for the flaws created by, for example, dislocation of carbon atoms, or the presence of impurities.

Laboratory growth of gemstone quality diamonds existed before Carnegie's invention, but it was much slower. Lab-grown monocrystalline diamonds grow epitaxially, layer-by-layer, on the face of an existing diamond. As the monocrystalline diamond grows, it does so in one direction, with the growth surface moving up and away from the diamond seed. While that happens, other carbon material accrues on its sides. That material accruing on the sides and not the growth surface will be non-monocrystalline. That is just as true now as it was

before Carnegie's invention.

Carnegie's discovery was that precise control of temperature gradients on the growth surface can greatly increase the *rate* at which the monocrystalline diamond grows. The temperature gradients must be maintained below certain levels to achieve the rate increase. The claims in this appeal recite that inventive method of diamond production in terms of two steps: (1) controlling the temperature of the growth surface such that all gradients are below 20º C, and (2) growing single-crystal diamond on that growth surface.

This case began when Carnegie and its partner M7D sued Fenix for importing diamonds that Fenix's supplier Nouveau produced in India with Carnegie's patented method. The record includes Nouveau's own images of the grown diamonds, its explanation of its equipment and how it uses it, and a report from Carnegie's expert explaining how, based on that evidence, Nouveau controlled its growth-surface temperatures.

Central to the district court's summary judgment of noninfringement was its flawed construction of "growth surface." It ignored the specification's constant drumbeat that *the* growth surface is one of the surfaces of the diamond crystal, and not some amalgam of surfaces. Despite the patent's repeated reference to the growth surface as the "top surface," the district court understood growth surface to mean "outer" surface, and it construed the term to encompass all surfaces upon

which material is accruing, i.e., the top surface where monocrystalline diamond grows, and the sides and edges where non-monocrystalline diamond grows. That flawed construction doomed Carnegie's case because it led the district court to conclude that Nouveau was not growing single-crystal diamond on the growth surface because substantial amounts of non-monocrystalline material was also accumulating on side surfaces.

The district court's alternative rationale was just as flawed. It saw no factual dispute about whether Nouveau was controlling the temperature of the growth surface. While the district court agreed with Carnegie that the claimed "control" did not require active measurement of surface temperatures, it turned around and said one could draw an inference from Nouveau's purported lack of measurement that it was not, in fact, controlling the surface temperature. Drawing that inference in favor of Fenix was legal error. Even worse, the inference itself is doubtful given the district court's separate conclusion that the parties genuinely disputed whether temperature control was possible without measurement. Finally, the district court further erred when it weighed that improper inference against the supposed lack of evidence pointed to by Carnegie. Carnegie in fact pointed to significant evidence, so significant that the district court relied on it in another context to find a genuine dispute on a different fact.

This Court should correct the district court's flawed claim construction, and

its flawed assessment of the temperature-control evidence, and remand for further proceedings.

JURISDICTION

The district court had jurisdiction over this patent-infringement case under 28 U.S.C. §§ 1331 and 1338(a). This Court has jurisdiction over Carnegie's appeal under 28 U.S.C. § 1295(a)(1) because the district court issued a final judgment on August 13, 2021 that resolved all pending claims, Appx1. Carnegie filed a timely notice of appeal on August 24, 2021. Appx2119-2121.

STATEMENT OF ISSUES

Did the district court commit legal error by granting Fenix's motion for summary judgment of noninfringement of the '078 patent based on:

1. An erroneous construction of the term "growth surface" that ignored the patent's own distinction between surfaces and meant that non-single-crystal diamond accruing on the *sides* of a diamond could nevertheless be considered as growth on the "growth surface"; and

2. An erroneous "inference" that the district court drew in Fenix's favor in violation of bedrock summary judgment principles and then weighed as the only evidence on the temperature-control limitation despite Carnegie's extensive countervailing evidence.

STATEMENT OF THE CASE

I. Carnegie and M7D

Carnegie is a renowned research institution headquartered in Washington, D.C. that dates back to 1904. Researchers at Carnegie developed the use of microwave plasma chemical vapor deposition (MPCVD) technology at issue in this case, which enables faster growth of high-quality diamond in laboratory settings and makes lab-grown diamonds a viable option for the gemstone industry. Appx96 (1:64-2:4). Three Carnegie researchers and a collaborating professor from the University of Alabama patented their ground-breaking methods and assigned the '078 patent to Carnegie. Appx86 ((75), (73)).

Carnegie partnered with M7D to commercialize the patented technology. Appx160 (¶¶6-7). M7D is a technology company founded in 2008 and based in Beltsville, Maryland. Appx159 (¶3). Carnegie granted M7D an exclusive license to the '078 patent in 2011. Appx160 (¶6). This brief refers to Carnegie and M7D collectively as Carnegie.

II. The '078 patent: A method for diamond production

The '078 patent describes improved methods for growing large, high-quality, single-crystal (monocrystalline) diamonds. Appx96-97 (1:64-2:4, 2:45-3:13), Appx102 (13:38-14:7). Lab-grown monocrystalline diamonds can be of suitable quality for use as gemstones, whereas lower-quality diamonds with

polycrystalline structure are typically used in industrial applications. Appx1178-1179 (¶101). As the ’078 patent explains, MPCVD methods known at the time of filing could produce gemstone quality diamonds only at slow rates, typically a few micrometers (microns) per hour. Appx96 (1:52-54). Faster processes existed, but they could produce only polycrystalline diamonds. *Id.* (1:54-56). In contrast to those methods, the methods described by the ’078 patent produced single-crystal diamond at much higher rates, with the patent reporting one exemplary “growth rate of 58 microns per hour.” Appx102 (13:57-59). As the inventors reported at the time of the invention, the patented process was capable of growing diamonds from 50 to 150 microns per hour, “up to 2 orders of magnitude higher than standard processes for making polycrystalline MPCVD diamond.” Appx1036. (Yan).[1]

The method described in the ’078 patent involves the control of temperature gradients across the growth surface of the diamond. Appx98 (6:51-54). The patent teaches that a high growth rate of single-crystal diamond can be achieved when all temperature gradients across the growth surface of the diamond are less than 20 °C. Appx86 (Abstract), Appx96-97 (2:66-3:5, 3:8-13), Appx102-103 (Claim 1). In

[1] “Yan” (Appx1036-1038) is a paper by the inventors of ’078 patent entitled “Very High Growth Rate Chemical Vapor Deposition of Single-Crystal Diamond,” which provides additional information about the diamond material produced in the examples of the ’078 patent, and which the ’078 patent incorporates by reference. Appx102 (14:43-49).

other words, the temperatures across the growth surface do not differ by more than 20º C. The patented process results in substantially single-crystal diamond grown on the growth surface with only "a small degree of polycrystallinity localized at the top edges of the diamond." Appx86 (Abstract), Appx102 (13:66-14:1).

The '078 patent describes MPCVD systems that can be used to practice the claimed methods. Some systems have a microwave power source and a chamber with a holder assembly that includes a "stage" and a "sheath" made of highly thermally conductive material. Appx97 (4:12-34; 4:44-50). The sheath makes thermal contact with a side surface of the diamond and holds it in place while acting as a heat-sink. *Id.* (4:48-55). There can also be a mechanism to cool the stage. *Id.* (4:34-43). The growth process begins with a small piece of manufactured or natural diamond referred to as a "diamond seed." Appx97 (4:56-59, 4:64-67). The seed is placed in the holder and the "top surface or growth surface" of the diamond is initially the top of the diamond seed and then the top of the grown diamond portion as the diamond grows. Appx97 (4:64-65).

The diamond growth process occurs as "step growth," which refers to growth of smooth diamond without "outcroppings" or twins (i.e., polycrystalline structure). *See* Appx101-102 (12:47-13:13) ("[D]iamond growth is usually continued as long as a 'step growth' condition can be maintained," meaning that "diamond is grown on the growth surface of the diamond such that the diamond is

smooth in nature, without isolated 'outcroppings' or twins.") (reference numbers omitted). The process can be stopped after step growth is exhausted, and the decision to stop can be based on growth amounts (a dimensional measurement or optical property) or processing time. *See id.* (processing "occurs *until it is determined* that the diamond has reached a predetermined thickness" "based on an actual measurement via mechanical or optical devices" or "*based on the length of processing time* in view of known growth rates for the growth process" (emphases added)).

The patent several times explains that the "growth surface" "is the top surface of the growing diamond portion." Appx101 (11:3-7).[2] The '078 patent and incorporated Yan article also call the growth surface the "deposition surface" and use the term to describe the top plane (the "<100>" planar surface) of the seed, at first, and then of the grown diamond. Appx102 (13:43-46) ("The deposition surface was within two degrees of the {100} surface of the diamond seed."). The patent differentiates growth that occurs on surfaces other than the "growth surface," for example on the side surfaces (such as the "<010>" planar surface) and

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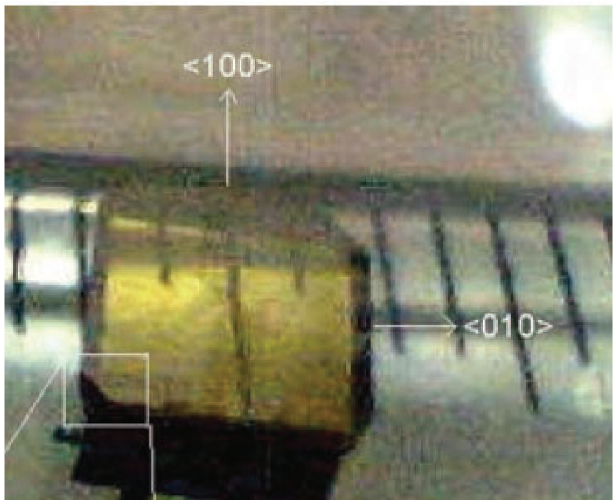
[2] *See also* Appx101 (12:9-11, 12:12-15) (same), Appx97 (4:59-62 ("the top surface or growth surface of the diamond 136 is positioned within a region of the plasma…"), 4:64-67 ("The top surface or growth surface of the diamond 136 is initially the diamond seed portion 138 and is then the grown diamond portion 140 as the diamond grows.")).

the corner surface (the “<111>” planar surface). The patent explains that “growth morphology indicated that the <100> side growth rate was faster than the <111> corner growth rate.” *Id.* (13:59-62). In Yan Figure 1, the top plane and a side plane are labeled (<100> and <010>) and a corner plane (<111>) is boxed:



Appx1037. Yan further explains that single-crystal diamond is produced on the growth surface (the top plane), whereas non-monocrystalline growth (e.g., polycrystalline diamond and diamond-like carbon material) occurs on the other edges and corners:

> [A]ny polycrystalline character of the CVD diamond is localized on the edge. Moreover, the corner magnification in Fig. 1 shows that considerable spherical diamond-like carbon exists on the edge and corner, ***but the top edge is sharp and straight***. After polishing off the small amount of black diamond-like carbon, which broadens the XRD peak width, our CVD diamond is a single crystal.

Id.

The patent describes equipment used to monitor process conditions. A measurement device, such as an "infrared pyrometer," can monitor the temperature of the diamond during the growth process without contacting the diamond. Appx98 (6:4-9). The pyrometer "takes a measurement of the growth surface, which is the top surface of the growing diamond portion 140, and provides the measurement to [a] main process controller 146." Appx101 (11:3-7).

The patent also describes equipment used to control process conditions. The main process controller takes a temperature measurement and input "from other measuring devices of other components in the diamond production system 100 and carries out executive level control over the process." Appx98 (6:25-31). "Based upon temperature measurements from the pyrometer 142, the main process controller 146 controls the temperature of the growth surface such that all temperature gradients across the growth surface are less than 20° C…." Appx98-99 (6:65-7:4).

The '078 patent lists several factors that affect temperature gradients:

> The ability to control all of the temperature gradients across the growth surface of the diamond is influenced by several factors, including:
>
>> [1] the heat sinking capability of the stage,
>> [2] the positioning of the top surface of the diamond in the plasma,
>> [3] the uniformity of the plasma that the growth surface of the diamond is subjected to,

> [4] the quality of thermal transfer from edges of the diamond via the holder or sheath to the stage,
> [5] the controllability of the microwave power, coolant flow rate, coolant temperature, gas flow rates, reactant flow rate and
> [6] the detection capabilities of the infrared pyrometer.

Appx98 (6:55-66) (paragraph structure and numbering added; reference numerals omitted). The main process controller thus controls temperature gradients by adjusting one or more of the microwave power, the coolant flow, the coolant temperature, gas flow rates, and reactant flow rate. *Id.* (6:65-7:4).

Even when controlling growth surface temperature gradients, the patented process results in some non-monocrystalline growth. Appx102 (13:66-14:1). Another patent in this field likewise indicates that peripheral growth with MPCVD processes was known and expected, and that multiple seeds grown together can become "interconnected by a polycrystalline diamond layer deposited from the gas phase" on the peripheries and "must be separated upon conclusion of the growth." Appx1410 (U.S. Patent No. 10,100,433, 1:36-41).

Plaintiffs assert six claims of the '078 patent in this case, claims 1, 6, 11, 12, and 16. Claims 1 and 12 are independent and recite:

1. A method for diamond production, comprising: controlling temperature of a growth surface of the diamond such that all temperature gradients across the	**12.** A method for diamond production, comprising: controlling temperature of a growth surface of the diamond such that all temperature gradients across the

growth surface are less than 20° C.; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr.	growth surface are less than 20° C.; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a temperature of 900-1400° C.

Appx102-103 (14:64-15:4, 15:31-37).

III. Fenix

Fenix is a New York LLC that has described itself as "leading the diamond revolution, a rising star in the lab-grown sector, combining decades of diamantaire experience with production capabilities as a grower and global distributor." Appx160 (¶8) (citing https://fenixdiamond.com/about). Fenix imports and sells laboratory grown diamonds manufactured by Nouveau Diamonds LLP (Nouveau).[3] Appx2.

Despite extensive efforts, Plaintiffs were unable to inspect Nouveau's manufacturing plant to witness and assess Nouveau's manufacturing process in person. The record on Nouveau's process primarily consists of a joint affidavit signed by Bakulbhai Limbasiya and Chirag Limbasiya (Appx975-994) (the Limbasiya Affidavit) who are affiliated with Nouveau and familiar with its

[3] This brief corrects misspellings of Nouveau's name in quotations without indication of the change.

manufacturing process. Appx14. The record also includes deposition testimony from Mr. Chirag Limbasiya, and pictures and videos produced by Fenix and discussed in the report of its expert J. Michael Pinneo. Carnegie's expert, Dr. Michael Capano, addresses the same evidence in his report.

According to the Limbasiya Affidavit, Nouveau places its diamond seeds "on the flat upper surface of a substrate plate." Appx976 (¶5.A); Appx979 (View 1); *see also* Appx944-945 (¶126); Appx951 (¶180). A typical batch begins with at least seeds. Appx981. Nouveau runs its manufacturing process for about hours and its diamonds have a "central crystal region" surrounded by a "dense polycrystalline region" at the end of the manufacturing period. Appx977 (Limbasiya Affidavit ¶5.N). As the witness declaration explains, the product has "lots of polycrystalline growth that must be cut off." *Id.* (¶5.O).

Nouveau uses much of the same equipment disclosed in the '078 patent. For example, Nouveau uses an "infrared pyrometer … above the deposition chamber" that "points at the center of one growth surface." Appx976 (¶5.A). While Nouveau claims it does not compute or measure temperature gradients, Appx977 (¶5.K), it "controls growth with a controller" that "tries to keep temperature at ~ °C," Appx976 (¶5.G).

As time proceeds during Nouveau's manufacturing runs, non-monocrystalline growth results on the edge and corners of Nouveau's single-

crystal cores—the processes are to maximize yield. The overgrowth ultimately becomes an issue and prevents Nouveau from accurately measuring temperature (due to the different thermal properties of the single-crystal cores and non-monocrystalline peripheral growth). According to the affidavit:

> We have difficulty measuring center to edge growth surface temperature ***once*** ***polycrystalline diamond grows***. (1) The emissivity of the dense polycrystalline region is bigger than the emissivity of the central crystal region but the pyrometer can only have one emissivity setting at a time. (2) The dense polycrystalline region has a blister shape. This confuses the sensor.

Appx977 (¶5.N).

IV. This litigation

A. Carnegie sued Fenix for infringing the ’078 patent

Carnegie filed this lawsuit in the Southern District of New York in January 2020 and asserted two Carnegie patents licensed by M7D, the ’078 patent and a second reissue patent that has since been dropped from the litigation. The amended complaint (Appx159-177) asserted that Fenix infringes the ’078 patent by, *inter alia*, importing products that are made by a process that satisfies one or more claims of the ’078 patent. Appx169-170 (¶63) (citing 35 U.S.C. § 271).

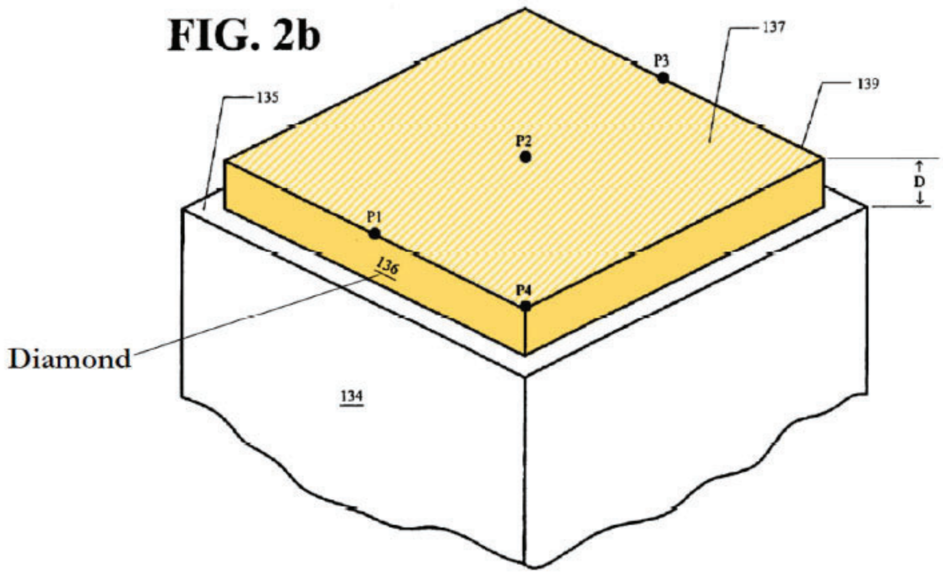
In April 2020, the parties filed claim construction briefs disputing, among other things, the meanings of “single-crystal diamond” and “the growth surface” in the ’078 patent. Appx219-220; Appx251-252.

B. The district court's claim construction rulings

1. "growth surface"

Both asserted independent claims recite a "growth surface" where temperatures are controlled and where single-crystal diamond is grown. Appx102-103 (14:65, 15:1-2, 15:32, 15:35-36). Carnegie urged that "growth surface" be construed as "the diamond seed surface or diamond surface that is closest to the plasma, upon which single-crystal growth primarily occurs as the diamond grows." Appx235. Carnegie explained that the '078 patent uses the term "growth surface" interchangeably with "top surface," and that the patent describes that surface in terms of its proximity to the plasma in the growth chamber. Appx235-236. In further support, Carnegie reproduced Figure 2b from the patent (with shading added), which includes points P1, P2, P3, and P4 that are described as being located on the growth surface:

FIG. 2b



Appx236 (with yellow shading added to the diamond 136, and lighter shading on the growth surface 137).[4]

The district court rejected Carnegie's construction and instead construed "growth surface" in the '078 patent as "the surface upon which diamond growth is occurring," adopting Fenix's proposed construction. Appx51-53. The court understood the patent to equate "growth surface" with the "exterior surface of the diamond seed" which later "shifts outward as the hydrocarbon gases accrue onto the seed to form new diamond." Appx52 (citing Appx97 (4:64-67)). The district court did not acknowledge that the '078 patent never refers to an exterior surface

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[4] The shading on the figure was added during the district court proceedings and is not meant to identify confidential matter in this brief.

and never refers to outward growth.

2. "single-crystal diamond"

The asserted claims require that what is grown on the growth surface be "single-crystal diamond." Appx103 (15:1, 15:35). The claim construction dispute was whether that term should be defined by what it includes versus what it excludes. Thus, Carnegie urged that "single-crystal diamond" has "substantially single-crystal structure," while Fenix urged that it has "insubstantial polycrystallinity." Appx61. The district court noted there was little substantive difference between the constructions and decided against Carnegie based on a claim differentiation theory. Because the patent uses both terms "single-crystal diamond" (claims 1 and 12) and "substantially single-crystal diamond" (claims 36 and 57), the district court believed that the patent draws a distinction between the two terms that Carnegie's construction did not accommodate. Appx62. The district court did not acknowledge that the term in claims 36 and 57 is used to narrow the much broader term "diamond," i.e., without specifying any type of crystal structure, in claims 32 (Appx103) and 44 (Appx104).

The district court ultimately chose the phrase "having insubstantial non-monocrystalline growth," which had been advocated by a defendant who is no longer involved. Appx60-62.

3. "controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C"

Finally, both asserted claims require a step of controlling the temperature of the growth surface such that temperature gradients across the surface are less than 20° C. Appx102 (14:65-67), Appx103 (15:32-34). The dispute about that term was whether the temperature-control step required the temperature measurements identified by Fenix, and the district court concluded it did not. The court rejected, among other things, an argument from Fenix that the "temperature variation[] … 'between the edges and the middle of the growth surface'" must be the inputs used in the methods to maintain appropriate temperature. Appx48-49 (citation omitted). Fenix had argued that "plaintiffs' construction would allow 'the asserted claims [to] be infringed without the alleged infringer even trying to achieve temperature gradients less than 20° C.'" Appx50, n.9. According to the district court, however, "the Patent appears to define 'controlling' more broadly, mentioning that other inputs [i.e. factors] are also 'used' to control the gradients" beyond just gradients as inputs. Appx49. According to the district court, "the word 'control' … is plainly qualified by the other factors" disclosed in the patent. Appx50, n.9. The district court thus construed the phrase to mean "controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are maintained at less than 20° C." Appx51.

C. The district court's summary judgment ruling

Fenix moved for summary judgment of non-infringement arguing that (1) Nouveau does not 'grow[] single-crystal diamond ... on the growth surface' … since Nouveau grows diamond with substantial amounts of polycrystallinity," Appx13, and (2) Nouveau does not 'control [] temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C' …. [and] does not even attempt to maintain such gradients." Appx13-14. The district court granted summary judgement on both bases.

Regarding the first, although the asserted claims cover diamond production methods that require no specific equipment beyond a deposition chamber and instead require steps of temperature control and single-crystal diamond growth, the court focused on the *components* of Nouveau's and the '078 patent's deposition chambers (e.g., Nouveau uses a "flat substrate holder" while the '078 patent uses "sheath" that "is a holder"). Appx14-15 (emphasis omitted). The district court focused even more on the product resulting from Nouveau's -hour process, instead of the methods Nouveau performs during those manufacturing runs. *See, e.g.*, Appx16-17, Appx19 (discounting plaintiffs' expert's analysis because it was not conducted on "the diamonds as grown"). Based on its assessment of images produced by Nouveau, and relying on its earlier construction that meant *everything* grown was necessarily grown on the "growth surface," the district court said "one

can plainly see that the non-monocrystalline growth is extensive". Appx20 (citing Appx984-988 (Views 6-10)). According to the district court, "no reasonable factfinder could conclude that Nouveau 'grows single-crystal diamond … on the growth surface." Appx23. The district court highlighted the significance of its growth-surface construction when it specifically referred to "the interstitial substance" in Nouveau's "diamond bricks." *Id.* The district court was presumably referring to the materials *between* Nouveau's diamonds.

Regarding Fenix's second basis for summary judgment, Nouveau's supposed failure to practice the temperature-control limitation, the district court rejected several of Fenix's arguments but ultimately decided the issue against Carnegie. Fenix argued that a side-contact holder was needed to maintain gradients under 20º C, but the district court found that Carnegie's expert testimony raised a genuine dispute about whether that was true. Appx24. Fenix also asserted that Nouveau's polycrystalline growth must have resulted from gradients above 20º C, but the district court rejected that argument too because polycrystalline growth can occur for other reasons. Appx25-26. Finally, Fenix pointed to data created for the litigation supposedly showing that Nouveau's actual temperature gradients exceed 20º C. Appx26-27. But the district court excluded that evidence due to Fenix's earlier position that it could not access Nouveau's documents. Appx27-28

Ultimately deciding this issue against Carnegie, the district court referred to

an "inference that Nouveau does not maintain 20-degree temperature gradients," which it viewed as inevitable because "Nouveau does not even measure temperature gradients during diamond growth." Appx28. At the same time, the district court failed to acknowledge the evidence Carnegie had pointed to in support of its position that Nouveau did, in fact, control growth temperatures. The district court thus found that "no reasonable factfinder could conclude either that Nouveau 'grows single-crystal diamond … on the growth surface'" or "controls temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C." Appx29.

D. Fenix's invalidity counterclaims were dismissed and final judgment was entered

After the summary judgment ruling, Carnegie executed a covenant not to sue for the '078 patent that remains operative so long as the district court's claim construction ruling remains the law, and it moved to dismiss Fenix's invalidity counterclaims for the '078 patent. The district court granted that motion on July 29, 2020, Appx2110, issued an Opinion on that ruling in early August 2021, Appx2111-2118, and entered final judgement on August 13, 2021, Appx1.

SUMMARY OF ARGUMENT

The disputed claims have two basic limitations: controlling temperature of a growth surface to maintain temperature gradients below 20º C (the "temperature-control" limitation) (Appx102 (14:65-67)); and growing single-crystal diamond on

the growth surface (the "growth" limitation) (Appx103 (15:1-3)). The district court's summary judgment of noninfringement in Fenix's favor rested on multiple errors, at least one for each of those limitations. First, the district court misconstrued "growth surface" so that it reads on multiple *different* surfaces—anywhere growth of any kind is occurring—despite a clear distinction in the claims and specification between the "growth surface" and other surfaces of the growing diamond. It reached that construction by misreading the '078 patent as referring to an exterior surface or outward growth. The specification refers instead to the growth surface as a particular surface: the top surface, which is the surface facing the plasma. The district court apparently understood diamond growth to be like an onion, with layers added as the diamond expands. Instead, single-crystal diamond growth in the laboratory develops like a deck of cards, with each new layer deposited on the growth surface below it like each new card stacked on the deck.

With the faulty construction, the district court accepted Fenix's argument that Nouveau does not grow single-crystal diamond "on the growth surface" due to the presence of non-single-crystal diamond on the sides of the diamond, i.e., at the interstitial regions between diamonds grown in batches. The district court essentially looked at a picture with dark areas between grown diamonds and concluded that the diamonds themselves must be non-monocrystalline diamond. The district court's construction was the basis for that analysis. Whether what

grows on the growth surface in Nouveau's process is single-crystal diamond is a disputed question of material fact. At the very least, this case must be remanded for the district court to assess whether there is such a dispute under the correct construction.

Second, the district court erred when it concluded that there was no genuine factual dispute about whether Nouveau controlled the temperature of the growth surface of its diamonds. That error rested on multiple missteps. The district court drew an inference in Fenix's favor while it *ignored* Carnegie's evidence altogether. It concluded that, because Nouveau said it does not monitor temperature gradients during its process, an inference can be drawn that it does not control those gradients. But that inference is contrary to bedrock summary judgment principles, which require that the court view the evidence in the light most favorable to the non-movant, Carnegie, including drawing all reasonable inferences in Carnegie's favor. It was also contrary to the court's earlier conclusion that control in the patent encompasses indirect control. The district court added insult to injury when it weighed its impermissible inference against what it said was a lack of evidence pointed to by Carnegie. In fact, Carnegie pointed to extensive evidence, the very evidence the court viewed to create a genuine dispute on a different material fact. The district court's failure to consider or even address that evidence in this context was error.

STANDARDS OF REVIEW

This Court follows the law of the regional circuit when reviewing a district court's grant of summary judgement. *Enplas Display Device Corp. v. Seoul Semiconductor Co.*, 909 F.3d 398, 405 (Fed. Cir. 2018). The Second Circuit reviews a grant of summary judgment without deference. *Howley v. Town of Stratford*, 217 F.3d 141, 151 (2d. Cir. 2000). When summary judgment of noninfringement is based on a flawed claim construction, this Court must vacate and remand. *Edgewell Personal Care Brands, LLC v. Munchkin, Inc.*, 998 F.3d 917, 925 (Fed. Cir. 2021); *Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1305 (Fed. Cir. 1999).

Claim construction is reviewed without deference, but any factual findings underlying a claim construction are reviewed for clear error. *Teva Pharms. USA, Inc. v. Sandoz, Inc.*, 574 U.S. 318, 321-22, 332 (2015).

ARGUMENT

I. The district court erred when it construed "growth surface" to include areas of multiple surfaces

A. The specification distinguishes between different surfaces of the diamond

The district court construed "growth surface" as "the surface upon which diamond growth is occurring." Appx51-53. Its analysis focused on a dispute about the structural nature of the growth material—whether the growth surface is an area

of primarily single-crystal growth or an area of any growth. The district court explained that "small amounts of polycrystalline diamond will nonetheless grow in localized places on the diamond" and "*such areas* should still be included within the definition of 'growth surface.'" Appx52 (emphasis added).[5] According to the district court, the patent uses "growth surface" to "refer to the *entire surface* where hydrocarbon gases are accruing into new diamond," and the court believed its "claim construction must impart the same meaning." *Id.*

The district court thus adopted a construction that defines "the growth surface" as *all areas* on which any type of diamond growth occurs, even if those areas are scattered on different faces of the diamond. "The surface" in that construction refers collectively to the entire surface area of the diamond exposed to the plasma, i.e., the aggregate of all diamond faces, not a single face. The district court confirmed the broad scope of its construction throughout its summary judgment opinion, where it focused on growth in the interstitial regions between Nouveau's diamond seeds, i.e., growth on *side surfaces*. For example, the court

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[5] It cited parts of the '078 patent (1) mentioning "a small degree of polycrystallinity localized at the top edges of the diamond" Appx52 (citing Appx102 (13:66-14:1)), (2) describing the growth surface based on its physical location and not the structural nature of the growth material *id*. (citing Appx96 (2:12-65), Appx97 (4:56-67), Appx99 (7:5-23)), and (3) mentioning embodiments in which only polycrystalline diamond is grown and the growth surface is thus an area of polycrystalline growth Appx52-53 (citing Appx102 (13:25-26)).

found no basis "to conclude that Nouveau's non-monocrystalline growth is insubstantial" because "one can plainly see that the non-monocrystalline growth is extensive," citing pictures from Nouveau's declaration that point to side growth, including the picture reproduced below. Appx20 (citing Appx984-988). It later highlighted "the substantial interstitial regions that are obvious to the naked eye in Nouveau's diamond batches." Appx23.

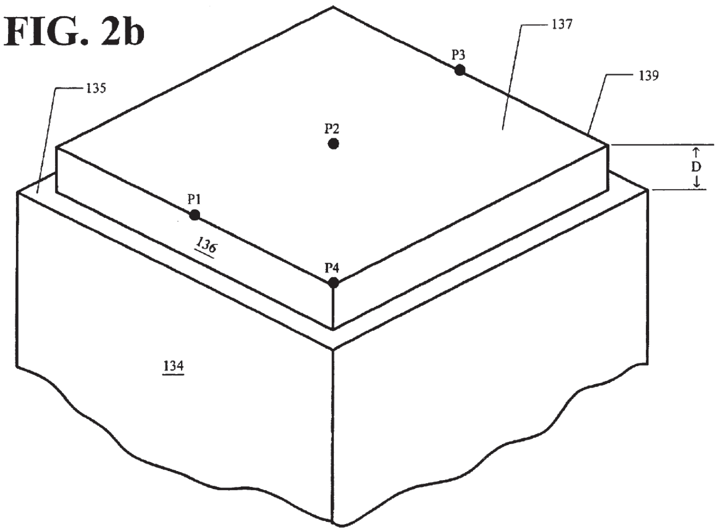
Appx985.[6]

[6] The portion of image within the highlighted box is confidential.

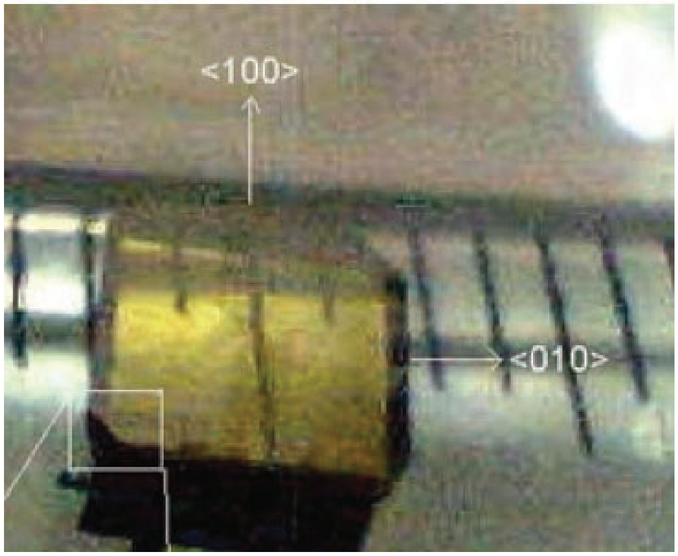
But this construction, under which all areas of diamond growth are "the growth surface," eliminates a clear distinction drawn in the claims and specification between the different surfaces of the diamond, and the inventors' choice to refer to *one* of those surfaces as the "growth surface" in the claims. For example, claims 21, 44, and 58 distinguish between "a side surface of the diamond" and the "edge of a growth surface." They require a holder that makes "thermal contact … with *a side surface* of the diamond adjacent to an edge of *a growth surface* of the diamond." Appx103 (15:65-67), Appx104 (17:19-22, 18:18-22). This same phrase is repeated throughout the specification. *See, e.g.*, Appx96 (2:14-18, 2:26-30, 2:36-40, 2:47-49), Appx97 (4:48-50).

The specification consistently uses "growth surface" to reference one side of the diamond. In three places, it describes temperature measurements "of the growth surface, which is *the top surface* of the growing diamond portion 140." Appx101 (11:3-7, 12:9-16) (emphasis added). It also describes the location of "*the top surface* or *growth surface* of the diamond" as "positioned within a region of the plasma …" Appx97 (4:59-62). And in Figure 2b, "the growth surface 137 of the diamond" is shown as the top face with "points P1, P2, P3 and P4." Appx99 (7:5-7).

FIG. 2b



Appx90. In the description of Example 1, moreover, the growth surface, which is sometimes called the "deposition surface," is described as "within two degrees of the {100} surface" and its growth rate is compared to growth on other parts of the diamond, namely, on the corner plane <111>. Appx102 (13:44-46, 13:59-62). Those planes were depicted in the Yan article incorporated into the specification, *id.* (14:43-59); the growth surface/<100> plane is on top, the corner plane/<111> was boxed, and a side plane/<010> was also labeled:



Appx1037. According to the patent, the "growth morphology indicated that the <100> side growth rate was faster than the <111> corner growth rate." Appx102 (13:59-62). The specification not only treats the top surface as the "growth surface," it recognizes growth outside the "growth surface" on the corner plane. The "growth surface" does not refer collectively to *all* areas of growth. This is consistent with the earlier description of "growth surface" as "the top surface of the growing diamond portion." Appx101 (11:3-7). It is not the whole "growing portion."

The specification "is the single best guide to the meaning of a disputed term." *Phillips v. AWH Corp.*, 415 F.3d 1303, 1315 (Fed. Cir. 2005) (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)). Yet the district court's construction erases the clear distinction in the patent between different surfaces and its use of "growth surface" to reference one of those

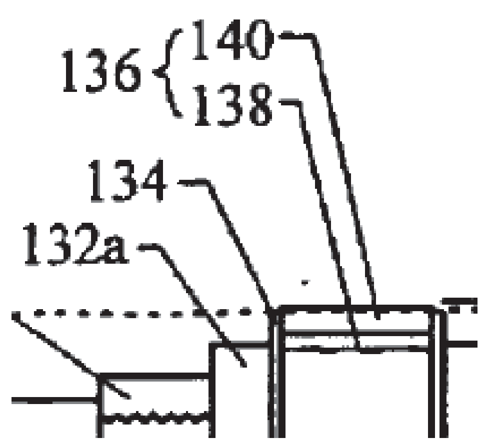
surfaces. Doing so is reversible error. *See AFG Indus., Inc. v. Cardinal IG*, Co., 239 F.3d 1239, 1249 (Fed. Cir. 2001) ("The primary error in the trial court's claim construction is that it eliminates the distinction between these terms that is set forth in the written description of the patent itself."). In *AFG*, the patent at issue distinguished between "layers" and "interlayers" on low-emissivity window coatings. *Id.* at 1248. Interlayers had "different physical attributes than 'layers,' because, being relatively thin, they do not 'substantially affect the optical properties' of the other layers." *Id.* The differing effect on optical properties was "the scientific and technical context for interpreting the meaning of the terms 'layer' and 'interlayer.'" *Id.* The district court's construction of "layer," however, did not account for optical effects, and its definition of "interlayer" likewise did "not account for the insignificant optical effect of the interlayers." *Id.*

Here too, the district court's construction disregards the scientific and technical context of the "growth surface." "Growth surface" refers to one discrete surface of the growing diamond—the top surface as the diamond is oriented in the patent's figures—which has a different growth rate than other surfaces. By adopting a construction that disregards the discrete nature of the growth surface, the district court eliminated the technical context in which "growth surface" is used. That error must be reversed.

B. The district court mischaracterized the specification and Carnegie's arguments

In reaching its construction of "growth surface," the district court mischaracterized both the specification and Carnegie's arguments. The district court seemed to view the growth as occurring in all directions, as if new layers were being added to an onion. For example, the district court reasoned that "[a]t the outset … the growth surface is the *exterior* surface of the diamond seed, but the surface growth then shifts *outward* as hydrocarbon gasses accrue onto the seed to form new diamond." Appx51-52 (citing Appx97 (4:64-67)) (emphasis added).

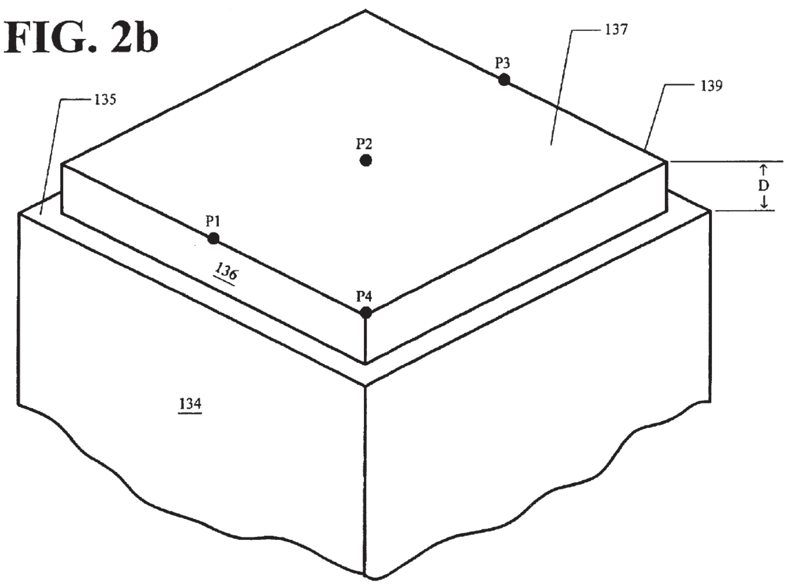
But the portion of the specification cited by the district court does not refer to the *exterior* surface of the diamond seed, it refers specifically to the "*top surface*" of the seed, and then of the grown diamond portion. Appx97 (4:64-66). To clarify, with reference to Figure 1, the patent identifies the "growth surface" as initially the top surface of the diamond seed portion, element 138, and then of the "grown diamond portion," element 140 in Figure 1 (right). *Id.*; Appx88 (Figure 1) (cropped and rotated to show detail). From both the text and the associated figure, the excerpt cited by the district court was not referring to the entire *exterior* surface, or *outward* growth, it was referring to the top surface, i.e., the growth surface, and the growth shown is upward only, not



outward. Instead of growth akin to a new layer all around an onion, the growth is more like an additional playing card added to the top of a deck.

The district court also pointed to language in column 7 to support the notion that the patent uses "growth surface" to refer to the "entire surface" exposed to the plasma and not a portion of the growing areas. Appx52 (citing, *inter alia*, Appx99 (7:5-23)). That part of column seven, however, refers to Figure 2b (below). Appx90, Appx99 (7:5-23).

FIG. 2b



As explained above, Figure 2b does not suggest that "growth surface" applies to the entire surface exposed to the plasma. Instead, "the growth surface" is element 137, which is the top layer. Appx99 (7:7). Contrary to the district court's assessment, there is no language in the patent to suggest that "growth surface" refers to the diamond's entire exterior surface, or any surface other than the

singular top surface.

The district court likewise mischaracterized Carnegie's position. According to the district court, Carnegie's proposed construction would "restrict the term to include only surface area where single-crystal diamond is growing." Appx52. That is wrong. Carnegie's proposed construction was "the diamond seed surface or diamond surface that is closest to the plasma, upon which single-crystal growth *primarily* occurs as the diamond grows." Appx51 (emphasis added). Carnegie did not define the "growth surface" as an area of only single-crystal growth. The proposal allowed for some non-single crystal growth on the "growth surface."

The proposal merely articulated that the "growth surface" is the only surface or side on which single-crystal growth is the "primary" one. On other surfaces, such as side surfaces, there is less control resulting in more non-monocrystalline growth such that single-crystal growth is not the "primary" growth. Carnegie used the last clause to distinguish among the different discrete surfaces of the diamond, as an identifier, the same way the first clause did. The first clause identified the growth surface by its location (closest to the plasma). The second identified it by the growth material. But the "growth surface" was always treated as the entirety of one discrete side or face—it is one of the diamond seed surfaces or diamond surfaces. The construction did not trim the growth surface down to something less than an entire face by dissecting out areas of non-

monocrystalline growth.

C. Under the correct construction, the question of whether Nouveau grows single-crystal diamond on its growth surface is disputed

When summary judgement is premised on an erroneous claim construction, the ruling should be vacated and remanded for further proceedings. *Kaneka Corp. v. Xiamen Kingdomway Grp. Co.*, 790 F.3d 1298, 1303 (Fed. Cir. 2015) ("Summary judgment should ordinarily be vacated or reversed if the district court bases summary judgment on an erroneous claim construction." (citing *Innovad Inc. v. Microsoft Corp.*, 260 F.3d 1326, 1335 (Fed. Cir. 2001))). Here, the district court based its summary judgment ruling on the view that "growth surface" encompasses all areas of growth on any surface of the diamond. It relied on pictures of all Nouveau's grown material and focused on the interstitial areas between its diamond seeds. *See* Appx20 (citing picture at Appx984-988), Appx23 (pointing to "substantial interstitial regions"). The district court never assessed growth occurring *only* on the top side of the growing diamond nor considered if any non-monocrystalline growth on that surface was insubstantial when compared to the other growth *on that surface*. That is pertinent analysis under the correct construction in which the "growth surface" is one single, discrete surface: "the diamond seed surface or diamond surface that is closest to the plasma, upon which single-crystal growth primarily occurs as the diamond grows."

Fenix never argued that non-monocrystalline growth on the top face was insubstantial relative to other growth on that surface. In fact, the very pictures Fenix presented, and the district court cited, show large single-crystal areas on the top surfaces surrounded by smaller non-monocrystalline edges. Fenix relied instead on the " batch" of diamonds that Nouveau produces—that is, the of growth resulting after a long, -hour process. *See, e.g.*, Appx841. Fenix premised its motion on the non-monocrystalline material resulting from this long growth process. But Nouveau's " batches" made after hours of growth are irrelevant under the correct construction of "growth surface." The case must be remanded to consider infringement under the correct construction.

II. There was a genuine dispute as to whether Nouveau controls the temperature of its growth surface as claimed

The district court's alternative rationale for granting summary judgment was based on the first limitation in the claims, i.e., the temperature-control limitation. According to the district court, "no reasonable factfinder could conclude … that Nouveau … 'controls temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20º C.'" Appx29 (quoting claim 1 of the '078 patent, Appx102 (14:64-67)).

In reaching that conclusion, the district court rejected all but one of Fenix's arguments. First, because Nouveau's system lacks a side-contact holder, Fenix

argued that such a holder is essential to maintain the claimed temperature gradients. The court disagreed, concluding that Dr. Capano's report created a genuine dispute of material fact about the need for a side-contact holder. Appx24. Second, the district court rejected Fenix's theory that Nouveau could not have maintained the claimed temperature gradients because its process produced substantial polycrystalline grown. Appx24-26 (reasoning that Nouveau's polycrystalline growth might have occurred "for some other reason"). And third, the district court rejected Fenix's argument based on "a self-serving subset of relevant documents," which the court excluded consistent with an earlier discovery ruling in Fenix's favor. Appx28 (relying on its earlier denial of Carnegie's motion to compel production of certain documents because it was not convinced Fenix could access Nouveau's documents and warning Fenix that it could not later use the supposedly unavailable documents at trial).

After it rejected most of Fenix's arguments, the district court's analysis of the temperature-control limitation came down to a single paragraph in its opinion with two fatal mistakes: it drew a factual inference in Fenix's, i.e., the movant's favor, and it ignored Carnegie's counter evidence.

A. The district court erred when it drew a factual inference in Fenix's favor

When deciding whether to grant summary judgment, "it is not within the province of the trial court … to resolve ambiguities and draw inferences in favor of

the movant." *LaFond v. General Physics Servs. Corp.*, 50 F.3d 165, 174 (2d. Cir. 1995). Instead, at the summary judgment stage, the trial court's role is to determine whether "a reasonable inference could be drawn in favor of the *nonmoving* party" sufficient to establish that a genuine issue of fact exists. *Howley*, 217 F.3d at 151 (emphasis added). The trial court here erred when it turned that fundamental rule upside down and expressly considered an inference in Fenix's favor.

When assessing the evidence regarding the temperature-control limitation, the district court first looked to Fenix's evidence and found dispositive a single sentence from the Limbasiya's declaration asserting that Nouveau does not "compute or measure temperature difference on the growth surface during normal growth." Appx28 (citing Appx977, ¶ 5K). But, as discussed below, *measuring temperature gradients* is not a claim limitation. Realizing that, the district court went further and crossed a line it should not have:

> The Court will consider the fact that Nouveau does not even measure temperature gradients during diamond growth, and this fact *supports an inference* that Nouveau does not maintain 20-degree temperature gradients.

Appx28 (emphasis added). The district court thus resolved an inference in Fenix's favor, and that inference is the only "evidence" on Fenix's side of the ledger.

Making matters worse, the inference the district court weighed in Fenix's favor was not even something Fenix had argued in its summary judgment briefing. Instead, it argued only that the absence of a side contact holder in Nouveau's

system, and the presence of polycrystalline diamond at the end of its growth process, demonstrated Nouveau's supposed failure to practice the temperature-control limitation. Appx850-852 (Fenix's opening brief in support of its summary judgment motion); Appx1526-1528 (Fenix's reply brief). The district court expressly rejected those arguments, yet it found Nouveau's process outside Carnegie's claims based on an inference it was not permitted to make on summary judgment. Appx24-26.

Fenix's failure to argue that the absence of temperature measurements means an absence of control was not surprising. The district court's claim construction order explicitly refuted the argument. It explained that "the ['078 patent] appears to define 'controlling' more broadly, mentioning other inputs that are also 'used' to control the gradients." Appx49 (quoting Appx98 (6:55-65)). The district court thus rejected the theory that the absence of temperature measurement meant the absence of control. It is simply baffling why, having construed "controlling temperature" to not require temperature measurement, the district court would later credit Fenix with an inference that there can be no control if there is no measurement.

B. The district court erred when it relied on a supposed lack of evidence showing that Nouveau practices the -temperature-control step

Against the improper and illogical inference in Fenix's favor, the district

court summarily stated that "plaintiffs point to no evidence from which a reasonable factfinder could conclude" that Nouveau practices the temperature-control limitation. Appx29. Without explanation or analysis, the district court cast aside Carnegie's evidence in the form of Dr. Capano's expert report, which the court earlier found created a triable issue of fact on another issue. It separately relied on Dr. Capano's report explaining how a system like Nouveau's, which allegedly lacked a side-contact holder, could practice the temperature-control limitation. Appx24. "Dr. Capano's report creates a genuine dispute of material fact as to whether it is possible to practice the 20-degree limitation without a side contact holder." *Id.* Yet five pages later, the district court somehow failed to discuss Dr. Capano's report when it said Carnegie pointed to "no evidence." In fact, Carnegie pointed to the same report. Appx1129-1130 (Carnegie's brief in opposition to Fenix's summary judgment motion).

In its opposition to summary judgment, Carnegie explained that "Dr. Capano presented affirmative evidence that Nouveau maintains infringing temperature gradients, namely proof that Nouveau performs steps to control temperature gradients …." Appx1129 (citing Carnegie's Statement of Material Facts, Appx1151 (¶¶ 96-99)). As Dr. Capano explained, his report "addressed evidence that Nouveau controls the temperature of the growth surface of a diamond during production …." Appx1185 (¶ 205). That evidence includes "direct evidence that

Nouveau moves the diamond to maintain its spatial relationship with the plasma ….” *Id.* Dr. Capano described how the particular growth chambers used by Nouveau are equipped to move the growth stage during operation, and that by doing so, “Nouveau controls the temperature of a growth surface of the diamond in its production process such that all temperature gradients across the growth surface … are less than 20º C.” Appx958 (¶¶ 197, 198).

Dr. Capano’s report addressed much more than the movement of the growth stage. He also discussed how Nouveau achieves the claimed temperature gradients through: (i) plasma uniformity; (ii) placement of the diamond seed such that their top surface uniformly interacts with the plasma; (iii) cooling of the diamonds while they are growing; and (iv) controlling plasma intensity. Appx954 (¶ 190). And he tied his discussion directly to the affidavit and images produced in the Limbasiya declaration. Appx954-958. Despite relying on Dr. Capano’s report earlier in its opinion, the district court addressed *none* of that evidence when it concluded that Carnegie had pointed to “no evidence” from which a reasonable fact-finder could conclude that Nouveau’s process meets the temperature-control limitation.

Unlike the district court, Fenix addressed Carnegie’s evidence when it advocated for summary judgment. Addressing that evidence generally (Appx1526-1528), Fenix argued that Dr. Capano’s “experiments” did not model Nouveau’s process. Appx1527. But that is irrelevant because Dr. Capano conducted his

experiments for the purpose of rebutting Fenix's evidence that the district court ultimately excluded. Appx1151-1153 (¶¶ 100-107). Separate from those experiments, Carnegie relied on an earlier part of Dr. Capano's report as evidence that Nouveau's process met the temperature-control limitation. Appx1129 (citing Appx1151 (¶¶ 96-99)). Fenix further pushed back on Dr. Capano's reliance on corrections to Nouveau's late-breaking temperature tests, produced after Fenix had convinced the district court it could not obtain such information. Appx1527 (discussing "temperature gradient measurements conducted by Nouveau" that the district court later excluded). But in those arguments, Fenix merely defended how Nouveau supposedly measured its growth surface temperature to arrive at the now-irrelevant data. Critically, at no point in its reply did Fenix address the particular evidence that Carnegie identified as supporting its infringement theory. The district court may very well have said nothing about Carnegie's evidence because Fenix gave it no argument to rely on. Regardless, the district court's conclusion rested on its assessment that Carnegie had not even "point[ed]" to evidence a reasonable factfinder could rely on. Appx29. That error cannot be an alternative basis to grant summary judgment in Fenix's favor based on an inference favorable to Fenix.

CONCLUSION

The Court should reverse the district court's grant of summary judgment in Fenix's favor and remand the case for trial under the correct construction of "growth surface." Alternatively, this Court should at least vacate the district court's grant of summary judgment and order the district court to proceed under the correct construction of "growth surface."

Respectfully submitted,

PERKINS COIE LLP

by /s/Nathan K. Kelley

Nathan K. Kelley

ADDENDA

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UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

CARNEGIE INSTITUTION OF WASHINGTON and M7D CORP.,

Plaintiffs,

-v-

FENIX DIAMONDS, LLC,

Defendant.

20-cv-200 (JSR)

FINAL JUDGMENT

JED S. RAKOFF, U.S.D.J.

Final judgment is hereby entered in this case, as the parties' remaining claims and counterclaims have been dismissed. See ECF Nos. 133, 140, 141. The schedule for briefing Fenix's remaining motion for attorney's fees is set as follows: opening brief to be filed by August 30, 2021, opposition brief by September 20, 2021, and reply brief by October 4, 2021.

SO ORDERED.

Dated: New York, NY
Aug 13, 2021

JED S. RAKOFF, U.S.D.J.

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

CARNEGIE INSTITUTION OF WASHINGTON and M7D CORP.,

Plaintiffs,

-v-

FENIX DIAMONDS, LLC,

Defendant.

20-cv-200 (JSR)

OPINION & ORDER

JED S. RAKOFF, U.S.D.J.

This suit concerns two patents for manufacturing diamonds in the laboratory. Carnegie Institution of Washington ("Carnegie") and M7D Corporation ("M7D") -- the assignee and licensee, respectively, of the patents-in-suit -- allege that Fenix Diamonds, LLC ("Fenix") infringed the patents by importing and selling diamonds that were manufactured by non-party Noveau Diamonds LLP ("Noveau") using the patented methods. Fenix now moves for summary judgment on plaintiffs' claims, arguing that Noveau's processes do not infringe the patents.

LEGAL STANDARD

The Federal Rules of Civil Procedure provide that a court "shall grant summary judgment if the movant shows that there is no genuine dispute as to any material fact and the movant is entitled to judgment as a matter of law." Fed. R. Civ. P. 56(a). "A fact is material if it might affect the outcome of the suit under the

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governing law, and an issue of fact is genuine if the evidence is such that a reasonable jury could return a verdict for the nonmoving party." Ramos v. Baldor Specialty Foods, Inc., 687 F.3d 554, 558 (2d Cir. 2012) (internal quotation marks omitted). The Court must "draw[] all reasonable inferences in favor of [the] non-movant." Heublein, Inc. v. United States, 996 F.2d 1455, 1461 (2d Cir. 1993). If "no reasonable trier of fact could find in favor of that party," then "summary judgment is proper." Id.

To demonstrate infringement of a patented method, a plaintiff must show that "all steps of the claimed method . . . [are] performed." Mirror Worlds, LLC v. Apple Inc., 692 F.3d 1351, 1358 (Fed. Cir. 2012). "Where there is a material dispute as to the credibility and weight that should be afforded to conflicting expert reports, summary judgment is usually inappropriate." Crown Packaging Tech., Inc. v. Ball Metal Beverage Container Corp., 635 F.3d 1375, 1384 (Fed. Cir. 2011). On the other hand, "[w]here the parties do not dispute any relevant facts regarding the accused [method] . . . but disagree over possible claim interpretations, the question of literal infringement collapses into claim construction and is amenable to summary judgment." MyMail, Ltd. v. Am. Online, Inc., 476 F.3d 1372, 1378 & n.1 (Fed. Cir. 2007) (quoting Gen. Mills, Inc. v. Hunt-Wesson, Inc., 103 F.3d 978, 983 (Fed. Cir. 1997)).

Because a summary judgment motion turns on whether factual disputes exist, the Court must consider the factual assertions propounded by each party and the evidence proffered by each party to support those assertions. The Court does not, and usually could not, review the entire factual record. Instead, the moving party must identify the undisputed facts and the evidence that supports them. To that end, the Southern and Eastern Districts of New York have adopted Local Rule 56.1, which requires the moving party to provide "a separate, short and concise statement, in numbered paragraphs, of the material facts as to which the moving party contends there is no genuine issue to be tried." Local Civ. R. 56.1(a). The non-moving party must provide a correspondingly numbered counterstatement, id. R. 56.1(b), and each paragraph in the movant's statement "will be deemed to be admitted for purposes of the motion unless specifically controverted" in the counterstatement, id. R. 56.1(c). Each numbered statement or counterstatement "must be followed by citation to evidence which would be admissible, set forth as required by Fed. R. Civ. P. 56(c)." Id. R. 56.1(d).

Federal Rule of Civil Procedure 56, in turn, provides that a movant for summary judgment may cite to "particular parts of materials in the record, including depositions, documents, electronically stored information, affidavits or declarations, stipulations (including those made for purposes of the motion

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only), admissions, interrogatory answers, or other materials," but an opposing party "may object that the material cited to support or dispute a fact cannot be presented in a form that would be admissible in evidence." Fed. R. Civ. P. 56(c)(1)-(2).

FACTUAL BACKGROUND

Based on the patents-in-suit, the parties' Local Rule 56.1 statements and counterstatements, and the evidence proffered by the parties, the following facts are not subject to genuine dispute. Additional undisputed facts will be set forth, where relevant, elsewhere in this opinion.

A. The Parties

The plaintiffs, Carnegie and M7D, call themselves "pioneers in the laboratory synthesis of high-clarity diamonds." Am. Compl., ECF No. 16, ¶ 4. The defendant, Fenix, acquires and sells laboratory-grown diamonds manufactured by non-party Noveau. Def't's Responses to Pls.' Statement of Undisputed Material Facts, ECF No. 123 ("PSUF"), ¶¶ 30-31. Fenix does not itself manufacture diamonds. Pls.' Responses to Def't's Statement of Undisputed Material Facts, ECF No. 112 ("DSUF"), ¶ 39.

Plaintiffs allege that Noveau's diamond production techniques infringe plaintiffs' patents and that Fenix thus infringes the patents by selling the diamonds it obtains from Noveau. DSUF ¶ 40. Plaintiffs seek (1) declaratory judgment that Fenix has infringed the patents and done so willfully; (2) an injunction against

further infringement; (3) damages, including enhanced damages under 35 U.S.C. § 284; and (4) costs and attorney's fees under 35 U.S.C. § 285. Am. Compl. Prayer for Relief.

B. The '078 Patent

The two patents-in-suit disclose methods for producing laboratory-grown diamonds. PSUF ¶ 1. Diamonds can be grown in the laboratory using chemical vapor deposition ("CVD"). PSUF ¶ 2. A diamond manufacturer can perform CVD by using microwave generators as a power source and manipulating temperature and pressure conditions; this method is known as microwave plasma CVD ("MPCVD"). PSUF ¶ 3. A manufacturer can perform MPCVD in a deposition chamber where air is removed, PSUF ¶ 4, and where a small diamond "seed" is placed, PSUF ¶ 5, by pumping gases into the deposition chamber and applying microwave power, PSUF ¶ 6. During the growth process, the manufacturer can control temperature and pressure, and these controls (along with subsequent steps to improve the diamond, such as cutting and polishing) influence the properties of the lab-grown diamond. PSUF ¶¶ 7, 8. Lab-grown diamonds may have a single crystal (monocrystalline) or many crystals (polycrystalline). PSUF ¶ 9.

A single-crystal diamond is desirable for some applications, such as gemstones. PSUF ¶¶ 11, 12. One of the patents-in-suit, U.S. Patent No. 6,858,078, issued to Hemley et al. (Feb. 22, 2005), Kopinsky Decl. Ex. 2, ECF No. 99-2 (the "'078 Patent" or the

"Patent"), discloses a process for growing a synthetic monocrystalline diamond using MPCVD. PSUF ¶ 1. Prior to the '078 Patent, a single-crystal diamond could be grown using MPCVD, but attempts to grow single-crystal diamonds were either slow or unsuccessful (e.g., resulting in a defective or polycrystalline diamond). PSUF ¶¶ 11-12. The Patent identifies this problem, explaining that prior attempts to produce a single-crystal diamond at higher rates "result[ed] in heavily twinned single crystal diamonds, polycrystalline diamond, or no diamond at all." '078 Patent 1:58-59.

The '078 Patent claims to solve this problem with a key insight: by maintaining temperature gradients of less than 20° Celsius across the entirety of the growth surface, the inventors asserted that one could "create large, high-quality [single-crystal] diamonds with increased . . . growth rates." Id. 13:21-22.

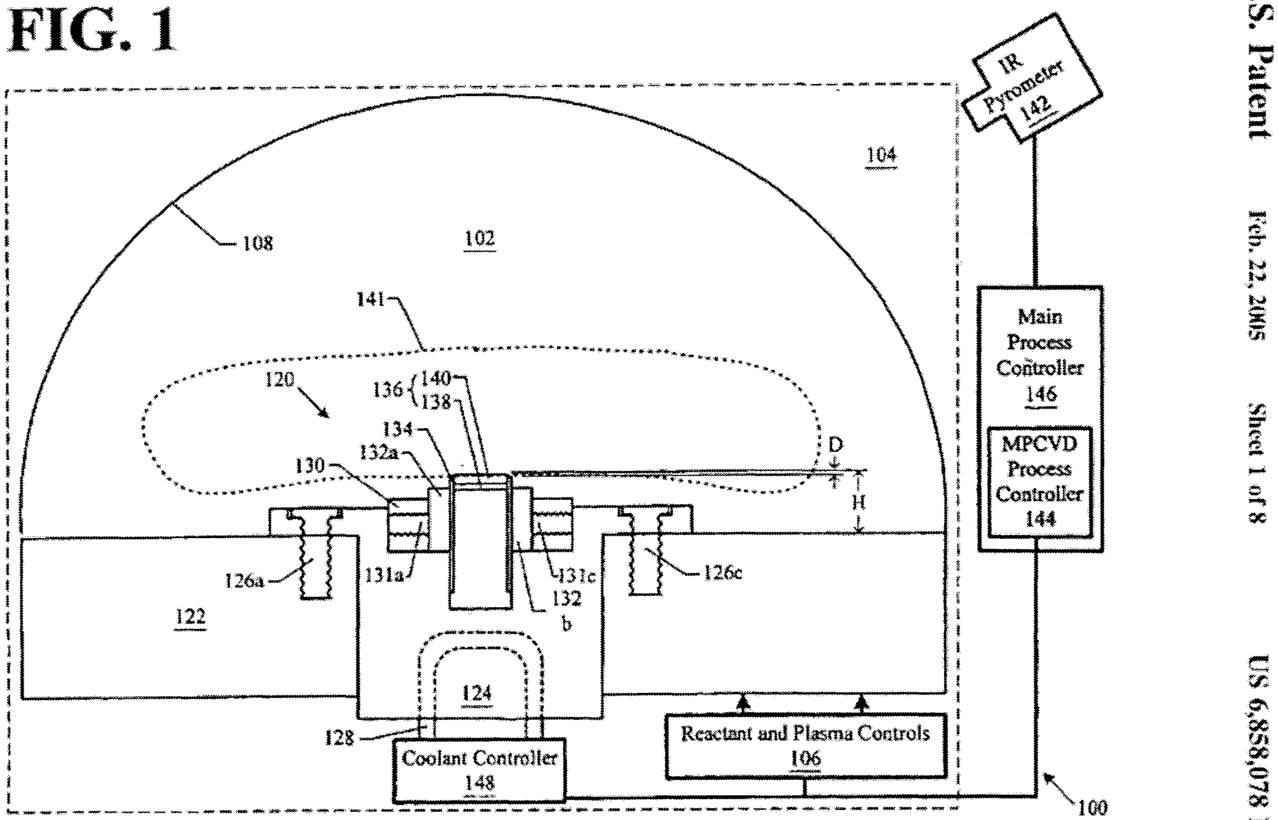
C. The Apparatus

Much of the '078 Patent is devoted to descriptions of apparatuses that could be used to practice the claimed techniques. See '078 Patent, Abstract (disclosing "[a]n apparatus for producing diamond in a deposition chamber," using various devices, "such that all temperature gradients across the growth surface are

less than 20° C”); id. Figs. 1-5; see generally id. at 3:19-13:35 (explaining figures).[1]

For example, Figure 1 “is a diagram of a diamond production system, according to an embodiment of the present invention, in which a deposition apparatus is depicted in cross section.” Id. at 3:64-67:[2]

FIG. 1



[1] Although the apparatuses are only embodiments of the claims, the Court, like the inventors, describes the apparatuses in order to aid the reader’s understanding.

[2] Throughout this opinion, quotations from the ‘078 Patent omit citations to numbered components of the figures.

The upper portion of the diagram depicts a bell-jar-shaped deposition chamber (108). Vacuum pumps (not shown) "draw[] out the air inside of the chamber." Id. at 4:18. Then, a set of "plasma electrodes" (not shown) generates plasma in the chamber. Id. at 4:19-20. A diamond "seed" rests in the deposition chamber, and the plasma flows over the top of the diamond seed, depositing new diamond growth. Id. at 4:64-67.

In the center of the chamber, on top of the deposition chamber floor (122), is the apparatus for holding the diamond seed, the "specimen holder assembly." Id. at 4:23-28; see also Fig. 2a (depicting the specimen holder assembly from a different angle). The specimen holder assembly includes a "stage" (124) made from a material with high thermal conductivity, such as molybdenum, which is attached to the deposition chamber floor. Id. at 4:31-34. Atop that stage is a "set ring" (130) which contains "set screws" that are used to tighten "collets," which, in turn, hold in place a "sheath" (134), also made of material with high thermal conductivity. Id. at 4:44-52. Inside the sheath is the diamond seed (136). Id. at 4:47-48. The Patent explains that "the sheath is a holder, which makes a thermal contact with a side surface of the diamond . . . and acts as a heat-sink to prevent the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond." Id. at 4:48-55.

In the upper-right of the diagram is an infrared pyrometer (142), "which is used to monitor the temperature of the diamond seed and later the grown diamond during the growth process without contacting the diamond." Id. at 6:6-9. There are also several computers with the capability to adjust the process in various ways. E.g., id. at 6:27-34. These include "the main process controller," which, "[b]ased upon temperature measurements from the pyrometer," "controls the temperature of the growth surface such that all temperature gradients across the growth surface are less than 20° C. by adjusting at least one of microwave power to the plasma, the coolant flow rate, coolant temperature, gas flow rates and reactant flow rate." Id. at 6:65-7:4.

In Figure 1, the diamond growth surface is a distance H above the deposition chamber floor and a distance D above the top edge of the sheath. Id. at 4:59-62, 5:1-3. The Patent teaches that the distance D should be kept within a certain range:

> The distance D should be sufficiently large enough to expose the edges of the growth surface of the diamond to the plasma. However, the distance D can not be so large as to prevent the heat-sinking effect of the sheath that prevents the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond. Thus, D should be within a specified distance range, such as 0-1.5 mm.

Id. at 5:3-9. "As the distance D increases" -- that is, as the diamond grows -- "the heat-sinking capacity of the sheath for the top edges of the growth surface of the diamond reduces." Id. at

7:66-8:2. In Figure 1, the distances D and H "are manually set using the screws of the set ring." Id. at 5:11-12. Therefore, "the growth process is periodically halted so that the position of the diamond can be adjusted downward with respect to the sheath . . . ." Id. at 8:6-8.

Figure 3 illustrates another embodiment of the claims. Many of the components of Figure 3 "are substantially the same" as in Figure 1. Id. at 8:28-29. However, Figure 3 has the purported advantage that one utilizing the apparatus in Figure 3 would not need to stop for manual adjustments to D and H. The apparatus depicted in Figure 3 has a "diamond actuator member" and a "holder actuator member," which can be used to raise or lower the diamond and sheath, respectively, thereby controlling distances H and D without needing to stop for manual adjustments. Id. at 10:5-11.

The Patent includes diagrams depicting the steps one would follow to use these apparatuses to practice the claimed techniques. Id. Fig. 6 (depicting the steps one would follow using the apparatus shown in Fig. 1; see id. at 10:55-58); id. Fig. 7 (depicting the steps one would follow using the apparatus shown in Fig. 3; see id. at 11:60-63).

D. The Claims

The '078 Patent includes dozens of claims, but plaintiffs argue only that Fenix has infringed two independent claims (claims 1 and 12) and certain claims dependent on them (claims 6, 7, 11,

and 16). DSUF ¶¶ 11, 12. The two independent claims asserted are:

- "Claim 1: A method for diamond production, comprising: controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr." '078 Patent 14:64-15:4.

- "Claim 12: A method for diamond production, comprising: controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a temperature of 900-1400° C." Id. 15:31-37.

In May 2020, the Court held a claim construction hearing pursuant to Markman v. Westview Instruments, Inc., 517 U.S. 370 (1996), and its progeny, and the Court adopted the following constructions:

- "Single-crystal diamond" is "a stand alone diamond having insubstantial non-monocrystalline growth." Opinion and Order, ECF No. 42, at 27.

- "The growth surface" means "the surface upon which diamond growth is occurring." Id. at 20.

- The phrase "controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C" means "controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are maintained at less than 20° C." Id. at 18.

- "[G]rowing single-crystal diamond . . . on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr" means "growing single-crystal diamond . . . on the growth surface,

which is set at a growth temperature and located in a deposition chamber with an atmosphere set at a pressure of at least 130 torr." Id. at 23-24.

- "[G]rowing single-crystal diamond . . . on the growth surface at a temperature of 900-1400° C" means "growing single-crystal diamond . . . on the growth surface, which is set at a temperature of 900-1400° C." Id. at 24.

E. **The '189 Patent**

The second patent-in-suit, United States Patent No. US RE41,189, issued to Li et al. (Apr. 6, 2010) (the "'189 Patent"), describes a method for repairing defects in lab-grown diamonds known as "annealing." Plaintiffs' operative amended complaint alleges that Noveau's manufacturing process infringes the '189 Patent. However, plaintiffs are no longer pursuing this claim. DSUF ¶ 12 ("Plaintiffs are no longer asserting that Fenix infringes the '189 Patent in this action.").

ANALYSIS

I. The '078 Patent

Fenix moves for summary judgment with respect to the '078 Patent on the ground that Noveau's manufacturing process does not infringe the patent, for two reasons. First, Fenix argues that Noveau does not "grow[] single-crystal diamond . . . on the growth surface" (a limitation on both asserted claims), since Noveau grows diamond with substantial amounts of polycrystallinity. Second, Fenix argues that Noveau does not "control[] temperature of a growth surface of the diamond such that all temperature gradients

across the growth surface are less than 20° C" (again, a limitation on both asserted claims). In Fenix's view, not only does Noveau not, in fact, maintain such gradients; Noveau does not even attempt to maintain such gradients.

To determine whether a reasonable factfinder could find that Noveau grows single-crystal diamonds on the growth surface, while maintaining 20° C gradients, the Court must look to the evidence concerning Noveau's manufacturing process.

A. Noveau's Manufacturing Process

In this respect, Fenix relies upon a joint affidavit signed by Bakulbhai Limbasiya and Chirag Limbasiya, Kopinski Decl. Ex. 5, ECF No. 99-5 (the "Affidavit" or "Aff."), as well as the deposition testimony of Chirag Limbasiya, ECF No. 129-2 ("C. Limbasiya Dep."). The Limbasiyas are affiliated with Noveau and familiar with its manufacturing process. *See* C. Limbasiya Dep. ¶ 1; Aff. ¶ 3. The Affidavit describes Noveau's manufacturing process as follows:

> Diamond seeds are on the flat upper surface of a substrate plate. One infrared pyrometer is above the deposition chamber. The pyrometer points at the center of one growth surface. . . . We don't move the pyrometer during growth.

Aff. ¶ 3.

Differences between Noveau's process and the process described in the '078 Patent are readily apparent. The Limbasiyas aver that Noveau places many diamond seeds together on a flat substrate holder, rather than placing a diamond seed in a sheath,

as depicted throughout the '078 Patent. Compare Aff. Views 2-4 with '078 Patent Figs. 1, 2a, 3, 5. Recall that the '078 Patent describes the importance of the sheath: "the sheath is a holder, which makes a thermal contact with a side surface of the diamond . . . and acts as a heat-sink to prevent the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond." '078 Patent 4:48-55 (emphasis added). The '078 Patent cautions that if the diamond growth extends too far above the sheath, this could "prevent the heat-sinking effect of the sheath that prevents the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond." Id. at 5:4-7[].

Of course, as the plaintiffs emphasize and Fenix concedes, the figures and embodiments in the '078 Patent are not limitations on its claims; the inventors' claims sweep more broadly than any particular illustration. Perhaps Noveau has discovered a way to practice the claimed methods without using a sheath. Still, the Court notes the lack of a sheath because it calls into question plaintiffs' claims: how can Noveau limit the temperature gradient without "a heat-sink to prevent the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond"? See id. at 4:48-55.

B. Growth of Single-Crystal Diamond on the Growth Surface

Fenix's response is simple: Noveau does not "prevent the formation of twins or polycrystalline diamond"; it accepts and deals with the polycrystalline material by cutting it off, polishing, and annealing. Therefore, Fenix argues, Noveau does not practice the patented method.

The Limbasiyas authenticate and describe several images of diamonds grown by Noveau. As the affiants explain, "[t]here is thick polycrystalline on each diamond." Aff. ¶ 5.E; see also Aff. Views 5-10 (showing the non-monocrystalline growth, which is visible to the naked eye). Indeed, plaintiff's own expert concedes that Noveau's diamond blocks contain "non-diamond or graphitized polycrystalline diamond," which "is something different than the single-crystal diamond material growing epitaxially at the growth surface, and [which] is cut away as it does not form part of the single crystal diamond portion." Capano Rpt., Kopinski Decl. Ex. 4, ECF No. 99-4, ¶ 172. Fenix argues that, because plaintiffs concede that Noveau's manufacturing process involves non-monocrystalline growth and because that growth is obviously not insubstantial, Noveau does not "grow[] single-crystal diamond . . . on the growth surface," a limitation on both asserted claims.

Carnegie offers three responses. First, Carnegie contends that the Affidavit and the Limbasiya Deposition are inadmissible. This argument is both mistaken and irrelevant.[3]

To begin with, the Affidavit and Limbasiya deposition, contrary to Carnegie's claim, clearly meet the threshold requirement for consideration on summary judgment, viz., that "the material cited to support or dispute a fact can[] be presented in a form that would be admissible in evidence." Fed. R. Civ. P. 54(c)(2). Plaintiffs offer no reason to doubt that the Limbasiyas' testimony regarding Noveau's manufacturing processes is made on personal knowledge and would be admissible on direct examination at trial. And Federal of Civil Procedure 56(c)(4) explicitly permits a movant or opponent to use an affidavit or declaration "on personal knowledge" if it "set[s] out facts that would be admissible in evidence, and show[s] that the affiant or declarant is competent to testify on the matters asserted."[4]

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[3] The Court, however, rejects Fenix's assertion that the Affidavit is notarized and is, therefore, a self-authenticating acknowledged document admissible under Federal Rule of Evidence 902(8). To be sure, when a party offers into evidence a self-authenticating document, the proponent need not otherwise demonstrate the document's authenticity. But the party must still demonstrate that the document offers testimony that, if offered through live testimony at trial, would be admissible in all other respects, such as relevance, the witness's competency, etc.

[4] The Court also rejects plaintiffs' argument that the deposition transcript is not properly considered on this summary judgment record. In a teleconference on October 29, 2020, plaintiffs informed the Court that, pursuant to a Hague Convention request

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Furthermore, even if all of plaintiffs' evidentiary arguments prevailed and the Court excluded the Limbasiyas' Affidavit and deposition testimony at the summary judgment stage, that would not change the result. Plaintiffs must point to some evidence from which a reasonable factfinder could conclude that Noveau grows single-crystal diamond on the growth surface, and plaintiffs offer no such evidence. Granted, Dr. Capano, one of plaintiffs' experts, performed a rocking-curve analysis and concluded that some of Noveau's diamonds "have insubstantial amounts of non-monocrystalline growth." PSUF ¶ 43. But, as plaintiffs concede,

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issued several months earlier, they were scheduled to depose Chirag Limbasiya in India in November 2020. Plaintiffs sought leave to proceed with the deposition after the Court-ordered close of discovery, and Fenix did not oppose the request. The parties contemplated (correctly) that the deposition would be complete after the summary judgment motion had been briefed. All parties indicated that they did not think the deposition would affect the summary judgment proceedings. However, plaintiffs' counsel indicated that plaintiffs imagined that this deposition testimony would be used the same way other deposition testimony had been used in the case; if it was capable of being reduced to admissible evidence, then the parties would cross that bridge at that time. At oral argument on Fenix's summary judgment motion, plaintiffs' counsel indicated that plaintiffs would provide the deposition testimony to the Court once formal translation was complete. In January 2021, the parties notified the Court that they had received a copy of the deposition transcript, and the Court permitted the parties to file excerpts from that deposition. Apparently disappointed with Limbasiya's testimony, plaintiffs now ask the Court not to consider the Limbasiya deposition. Consistent with plaintiffs' previous position, however, the Court will treat the deposition transcript no differently than other evidence offered in support of or opposition to summary judgment. In any event, the Limbasiya deposition is cumulative because the Court would reach the same result on this motion based on the Affidavit alone.

the rocking curve analysis was conducted "on a finished-diamond sample," Pls.' Opp. to Mot. for Summ. J., ECF No. 108, at 7, i.e., a sample collected after Noveau removed the non-monocrystalline regions. Similarly, plaintiffs cite Fenix's marketing claims that its diamonds are of the "highest quality" and Fenix's admission in this case that, when it ultimately sells the diamonds, they have insubstantial polycrystalline diamond and insubstantial graphite inclusions. PSUF ¶¶ 40, 110, 111. However, because this evidence relates exclusively to the finished product, not to the diamonds as grown, it is neither disputed nor relevant to the question presented: whether Noveau grows single-crystal diamond on the growth surface.

Second, plaintiffs argue that the parasitic growth on the interstices of Noveau's diamond blocks is to be expected and is, therefore, "insubstantial" (or, at least, that there is a genuine dispute of material fact regarding substantiality). Plaintiffs' expert opines that "[u]nder [Fenix's] interpretation, it would be impossible to grow single crystal material via MPCVD because polycrystalline growth on the edges (e.g., 010 faces) during MPCVD is inevitable." Capano Rpt., Kopinski Decl. Ex. 4, ECF No. 99-4, ¶ 280. Plaintiffs argue that "[a]pplying Fenix's logic would thus have an absurd result: no MPCVD diamond process could ever infringe because of a necessary byproduct, one that isn't necessarily even diamond at all." Opp. 7-8.

This argument is one part slippery slope fallacy and one part motion for reconsideration. The slippery slope aspect of the argument is unsound because the "absurd result" plaintiffs fear is not, in fact, absurd. Perhaps it is the case that "no MPCVD diamond process could ever infringe because of a necessary byproduct"; that would just mean that the Patent is non-enabled, a question the factfinder will resolve at trial. But the slippery slope argument is also unsound because Fenix does not argue that the patented method produces _no_ non-monocrystalline growth, only that it produces _insubstantial_ monocrystalline growth. And plaintiffs offer no basis for a reasonable factfinder to conclude that _Noveau's_ non-monocrystalline growth is insubstantial; indeed, one can plainly see that the non-monocrystalline growth is extensive. _See_ Aff. Views 6-10.

The thinly disguised motion-for-reconsideration aspect of plaintiffs' argument is readily apparent in the words of plaintiffs' expert:

Court's Construction	**Plaintiffs' Construction**
"The construction of the term 'growth surface' must therefore not exclude polycrystalline growth." Markman Order, ECF No. 42, at 20.	"I do not interpret growth surface to include the non-diamond or polycrystalline diamond that grows at the periphery of the single crystal diamond." Capano Rpt., Kopinski Decl. Ex. 4, ¶ 173.

"Plaintiffs' proposed construction . . . would wrongly restrict [growth surface] to include only surface area where single-crystal diamond is growing."	"In my opinion, the growth surface is the region where single-crystal diamond grows . . . and does not include the surrounding areas."
Markman Order 19.	Capano Rpt. ¶ 167.
"Since the Patent uses [growth surface] to refer to the entire surface where hydrocarbon gases are accruing into new diamond, the claim construction must impart the same meaning."	"No, I am not willing to include the entire surface upon which hydrocarbon gases are accruing [in 'growth surface']. I think that's contrary to the Court's construction."
Markman Order 19.	Capano Dep. Tr., Kopinski Decl. Ex. 16, ECF No. 126-1, at 180:21-181:4.

At Markman, the Court construed "growth surface" to mean "the surface upon which diamond growth is occurring." Opinion and Order, ECF No. 42, at 20. Plaintiffs would instead construe the phrase to include only the surface on which single-crystal diamond growth is occurring. The Court rejects plaintiffs' disguised motion for reconsideration, which identifies no legal or factual basis for departing from the law of the case. Because plaintiffs' argument is premised not on a factual dispute but on a disagreement with the Court's claim construction, the question presented is a legal one and summary judgment is proper. MyMail, Ltd. v. Am. Online, Inc., 476 F.3d 1372, 1378 & n.1 (Fed. Cir. 2007).

Finally, plaintiffs argue that the Court should deny Fenix's motion for summary judgment because plaintiffs were not able to

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take possession of any raw diamond bricks before Noveau cut and polished them. Plaintiffs thus could not analyze the peripheral growth that Fenix claims is polycrystalline. See Quinn v. Syracuse Model Neighborhood Corp., 613 F.2d 438, 445 (2d Cir. 1980) ("At least when the party opposing the motion has not been dilatory in seeking discovery, summary judgment should not be granted when he is denied reasonable access to potentially favorable information.").

Plaintiffs chose to file this suit against Fenix and not against Noveau, and with that decision came certain risks. One of those risks was that plaintiffs would need to seek discovery from Noveau through the Hague Convention, rather than directly through this Court. The Court permitted plaintiffs every opportunity to seek such discovery, and in April of this year, the Court finally received a letter from the Indian Government enclosing the evidence plaintiffs obtained through the Hague Convention. Indeed, the deposition of Chirag Limbasiya, which plaintiffs now argue should not be considered on summary judgment, was obtained by plaintiffs through the Hague Convention. The Hague Convention process has now run its course, and to the extent plaintiffs tried, but were unable, to obtain diamond samples from non-party Noveau through the Hague Convention, plaintiffs ran that risk by suing Fenix and not Noveau.

Insofar as plaintiffs argue that Fenix controls Noveau and thus has access to, and should have produced, diamond samples, the Court has already rejected this argument. Memorandum Order, ECF No. 63 (denying plaintiffs' motion to compel production by Fenix). Plaintiffs offer no evidence to disturb the Court's prior conclusion that Fenix lacks the practical ability to require Noveau to turn over in-process diamond bricks.

Furthermore, plaintiffs fail to show how they would benefit from accessing the raw diamond. Dr. Capano, plaintiffs' expert, acknowledged that he thought the interstitial substance in Noveau's diamond bricks was some combination of polycrystalline diamond, polycrystalline graphite, and non-diamond carbon -- not single-crystal diamond. Capano Dep. Tr., Kopinski Decl. Ex. 16, ECF No. 126-1, at 178:3-11. Plaintiffs have not remotely suggested (let alone offered evidence to show) that the substantial interstitial regions that are obvious to the naked eye in Noveau's diamond batches might, in fact, be single-crystal diamond. Therefore, plaintiffs have not shown how they might create a genuine dispute of material fact by testing the diamond blocks.

For these reasons, no reasonable factfinder could conclude that Noveau "grows single-crystal diamond . . . on the growth surface," as the Patent uses those terms.

C. Maintenance of 20-Degree Temperature Gradients

As a second independent basis for summary judgment, Fenix argues that a reasonable factfinder would necessarily conclude that Noveau does not maintain 20-degree temperature gradients across the growth surface, a limitation on both asserted independent claims. Fenix offers three bases for this conclusion.

First, Fenix argues that a side contact holder is essential to maintaining the temperature gradient beneath 20° Celsius; Noveau uses an open holder design, making such a gradient impossible. To be sure, a side-contact holder is what the embodiments, figures, and examples of the '078 Patent had in mind. However, plaintiffs maintain that the 20-degree gradient does not require a side-contact substrate holder. They offer the expert testimony of Dr. Capano, who claims, based on a technique called finite element analysis, that it is possible to practice the 20-degree gradient limitation without using a side-contact holder. Dr. Capano's report creates a genuine dispute of material fact as to whether it is possible to practice the 20-degree limitation without a side-contact holder.

Second, Fenix recycles its prior argument that there is substantial polycrystalline growth. Thus, Fenix argues, the gradient must be greater than 20° Celsius. After all, Fenix points out, the purpose of the 20-degree gradient limitation was to eliminate or substantially reduce polycrystalline growth; if

Noveau's process produces substantial polycrystalline growth, then it must be because Noveau's gradients exceed 20° Celsius.

This argument adds nothing new. If (as the Court has already found) Noveau's process yields substantial non-monocrystalline growth on the growth surface, then Noveau's process does not infringe the Patent, regardless of whether the reason for that growth is a failure to practice the correct temperature gradient.

Furthermore, this argument is unsound because it exemplifies a logical fallacy known as "affirming the consequent." Here is an example of the fallacy:

1. *If the Yankees ever lose ten games in a row, then Judge Rakoff will paint his chambers a mournful gray.*
2. *Judge Rakoff's chambers are painted gray.*
3. *Therefore, the Yankees must have lost ten games in a row.*

The reasoning is unsound because it could be that the Yankees never lost ten games in a row (God willing), but Judge Rakoff's chambers were painted gray because that was the only color the General Services Administration would allow, or because Judge Rakoff wished the color to match his hair, or any of a dozen other reasons. Here, Fenix has committed the same fallacy:

1. *If the temperature gradients exceed 20° C, then there will be polycrystalline growth.*
2. *There was polycrystalline growth.*
3. *Therefore, the gradients must have exceeded 20° C.*

The reasoning is unsound because it could be that the temperature gradients were maintained at less than 20° C, but there was polycrystalline growth for some other reason (wrong temperature, wrong pressure, wrong mix of gases, etc.). Therefore, the Court rejects Fenix's argument that the polycrystalline growth demonstrates a failure to maintain the temperature gradient.

Finally, Fenix argues that undisputed record evidence demonstrates that Noveau neither limits its temperature gradients to less than 20° C nor even tries to do so. In this respect, the Limbasiyas aver that "Noveau [does not] compute or measure temperature difference on the growth surface during normal growth." Aff. ¶ 5.K. The affiants further aver that "Fenix asked us to try." Id. The result was that after about four hours of growth, the temperature at the periphery of the growth surface was 44° C greater than the temperature at the center of the growth surface, id. ¶ 5.L, and after about fifty-two hours of growth, the temperature at the periphery was approximately 51° C greater than the temperature at the center, id. ¶ 5.M.

Fenix's counsel produced to plaintiffs, purportedly on behalf of Noveau, related data on which Fenix now relies (e.g., thermal camera data allegedly showing temperature gradients that exceed 20° Celsius). Plaintiffs point out that this evidence was not produced by Noveau or its counsel and was not produced in response to any discovery request or through the Hague Convention.

Fenix's counsel has taken the position throughout this litigation that it does not represent Noveau. Plaintiffs object that the thermal camera data was created for the purpose of this litigation based on Fenix counsel's instructions to Noveau, but that communications between Fenix's counsel and Noveau have not been disclosed, leaving plaintiffs unable to probe the accuracy of the data Noveau produced for this litigation. Plaintiffs argue that, without the communications between Fenix's counsel and Noveau, plaintiffs have no reasonable way to cross-examine this data. Plaintiffs add that its experts Dr. Capano and Dr. Gleason contend that, without further information, the thermal camera data is unreliable.

Plaintiffs have the better of this argument. In July 2020, the Court denied plaintiffs' motion to compel production of certain documents by Fenix, finding that plaintiffs had not demonstrated, as a practical matter, that Fenix could access Noveau's documents; the Court adheres to that finding. See Memorandum Order, ECF No. 63. At the same time, however, the Court warned that "a party may not 'blow hot or cold' and, having persuaded the court in discovery of its inability to produce such documents, later seek to use them to help its case at trial." Id. at 2 (quoting Shcherbakovskiy v. Da Capo Al Fine, Ltd., 490 F.3d 130, 138 (2d Cir. 2007).

Concededly, the documents that Fenix persuaded the Court it could not produce last July are not the same documents at issue

here, but the principle the Court then articulated applies here. The Limbasiyas concede that it was Fenix who "asked us to try" making thermal measurements, and Fenix's counsel, not Noveau, ultimately produced the resulting data to plaintiffs outside the Hague Convention, yet Fenix failed to produce the communications between Fenix (or its counsel) and Noveau (or its counsel) which would provide necessary context for that data collection. The Court will not permit Fenix, based on its corporate relationship with Noveau, to produce and then rely upon a self-serving subset of relevant documents to demonstrate the temperature gradients that occur during Noveau's growth. The Court excludes all of Fenix's evidence purporting to show temperatures or temperature gradients during Noveau's diamond growth.

On the other hand, the Limbasiyas' simple testimony that "Noveau [does not] compute or measure temperature difference on the growth surface during normal growth," Aff. ¶ 5.K, does not suffer from the same problem. The plaintiffs were permitted to depose the affiants under the Hague Convention, and they did so. The Court will consider the fact that Noveau does not even measure temperature gradients during diamond growth, and this fact supports an inference that Noveau does not maintain 20-degree temperature gradients. Indeed, the Patent itself instructed the practitioner to measure temperature gradients during growth. '078 Patent 6:65-7:4 (noting that "the main process controller"

"controls the temperature of the growth surface such that all temperature gradients across the growth surface are less than 20° C," "[b]ased upon temperature measurements from the pyrometer"). Especially given that Noveau does not measure gradients, plaintiffs point to no evidence from which a reasonable factfinder could conclude that Noveau does, in fact, maintain gradients that do not exceed 20° C during growth.

For the foregoing reasons, the Court grants summary judgment to Fenix on plaintiffs' claims based on the '078 Patent because, construing all facts and drawing all reasonable inferences in plaintiffs' favor, no reasonable factfinder could conclude either that Noveau "grows single-crystal diamond . . . on the growth surface" or that it "controls temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C."

II. The '189 Patent

Although the operative Amended Complaint includes claims based on the '189 Patent, plaintiffs concede that they "are no longer asserting that Fenix infringes the '189 Patent in this action." DSUF ¶ 12. Plaintiffs are even willing to concede that the claims should be dismissed with prejudice and, at oral argument, plaintiffs represented that they had executed a binding covenant not to sue.

Nevertheless, the parties disagree about how the Court should dispose of plaintiffs' claims and Fenix's related counterclaims. Fenix argues that the Court should grant summary judgment in its favor because Fenix met its burden as movant to show the lack of a genuine dispute of material fact. Plaintiffs argue that the Court must dismiss the claims and counterclaims relating to the '189 Patent for lack of subject matter jurisdiction because, given the binding covenant, the dispute is moot and the Court lacks subject matter jurisdiction.

The Court begins with Fenix's counterclaims relating to the '189 Patent, which allege (1) that Fenix does not infringe the patent, (2) that the patent is invalid, and (3) that the patent is unenforceable because the '189 Patent (or its predecessor before reissue) was procured through inequitable conduct. These claims all arise under the Declaratory Judgment Act. In addition, Fenix seeks attorney's fees under 35 U.S.C. § 285.

The Federal Circuit has explained that "[a] useful question to ask in determining whether an actual controversy exists [in a case like this] is what, if any, cause of action the declaratory judgment defendant may have against the declaratory judgment plaintiff." Benitec Australia, Ltd. v. Nucleonics, Inc., 495 F.3d 1340, 1344 (Fed. Cir. 2007). In Benitec, as in the case at bar, a patentholder sued for alleged infringement and the defendant asserted counterclaims under the Declaratory Judgment Act.

However, after unfavorable developments for the plaintiff, it moved to dismiss its claims without prejudice under Federal Rule of Civil Procedure 41(a)(2). The district court granted the motion and dismissed the counterclaims for lack of subject matter jurisdiction under the Declaratory Judgment Act. The defendant appealed. Before the case was resolved on appeal, the plaintiff covenanted not to sue the defendant for any infringement predating the dismissal of the case by the district court. The Federal Circuit affirmed, finding that after the covenant, the plaintiff had no viable claims against the defendant, so the court lacked subject matter jurisdiction over the defendant's counterclaims under the Declaratory Judgment Act.

In the case at bar, given the binding covenant not to sue executed by plaintiffs and the fact that defendants' counterclaims arise under the Declaratory Judgment Act, Benitec controls. Accordingly, defendants' declaratory judgment counterclaims relating to the '189 Patent are dismissed for lack of subject matter jurisdiction. Defendants' claim for attorney's fees remains.

Plaintiffs' affirmative claims, however, are in a different procedural posture from those in Benitec. The Amended Complaint claims not only declaratory judgment but also monetary damages (among other relief); therefore, despite plaintiff's covenant,

their still-pending claims state an injury-in-fact sufficient to demonstrate standing.

Moreover, unlike the plaintiff in Benitec, who filed a Rule 41(a)(2) motion, here the plaintiffs do not offer a procedural vehicle for the dismissal of their claims. Rather, the plaintiffs argue that with an eleventh-hour covenant they can unilaterally deprive the Court of subject matter jurisdiction over claims for damages that remain pending before this Court.

Benitec does not support this proposition, nor is the Court aware of any case that does. The Federal Rules explicitly provide a mechanism for a plaintiff to unilaterally drop its claims by filing a notice of voluntary dismissal. See Fed. R. Civ. P. 41(a)(1)(A)(i). However, a plaintiff must do so before issue is joined. Here, the plaintiffs lost their ability to unilaterally dismiss their claims when Fenix filed its answer. Covenanting not to sue (or even covenanting not to prosecute this suit) does not offer a substitute for Rule 41(a)(1)(A)(i), nor, given that plaintiffs seek damages, does it deprive the Court of subject matter jurisdiction over plaintiffs' still-pending claims.

Therefore, the Court declines plaintiffs' oral motion to dismiss plaintiffs' claims relating to the '189 Patent. And there can be no doubt that Fenix is entitled to summary judgment on those claims; plaintiffs offer no evidence from which a reasonable factfinder could conclude that Noveau's methods infringe the '189

Patent. Accordingly, the Court grants summary judgment to Fenix on plaintiffs' claims relating to the '189 Patent.

For the foregoing reasons, Fenix's motion for summary judgment, ECF No. 97, is granted and the Court enters judgment for Fenix dismissing all plaintiffs' claims with prejudice. Fenix's counterclaims relating to the '189 Patent are dismissed for lack of subject matter jurisdiction, except insofar as Fenix seeks attorney's fees. Fenix's counterclaims relating to the '078 Patent were not the subject of any dispositive motion and will proceed to trial. The parties are directed to jointly call Chambers by June 21, 2021 to set a date for trial on Fenix's remaining counterclaims.

SO ORDERED.

Dated: New York, NY
June 16, 2021

JED S. RAKOFF, U.S.D.J.

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

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CARNEGIE INSTITUTE OF WASHINGTON et al.,

Plaintiffs,

-v-

PURE GROWN DIAMONDS, INC. et al.,

Defendants.

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20-cv-189 (JSR)

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CARNEGIE INSTITUTE OF WASHINGTON et al.,

Plaintiffs,

-v-

FENIX DIAMONDS, LLC

Defendant.

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20-cv-200 (JSR)

OPINION AND ORDER

JED S. RAKOFF, U.S.D.J.

"Diamonds are a girl's best friend,"[1] even if they are grown in a lab. At least this is the view of the plaintiffs in these consolidated actions, who describe themselves as "pioneers in

[1] From the song of the same title sung first by Carol Channing and then by Marilyn Monroe in, respectively, the Broadway musical *Gentlemen Prefer Blondes* (1949) and the Hollywood movie of the same name (1953). Aficionados of James Bond movies would want to add that boys are also often enamored of diamonds. See *Diamonds Are Forever* (1971).

the laboratory synthesis of high-clarity diamonds." PGD Compl. ¶ 4.[2] Plaintiff Carnegie Institute of Washington, a Washington, DC corporation, is the assignee of the two patents-in-suit. Id. ¶ 2. Plaintiff M7D Corporation, a Delaware corporation, is the licensee of both patents with rights to enforce them. Id. ¶ 6. Plaintiffs sue co-defendants Pure Grown Diamonds, Inc. and IIa Technologies PTE, Ltd. (collectively "PGD"), id. ¶¶ 92-141, as well as defendant Fenix Diamonds LLC ("Fenix"), Fenix Compl. ¶¶ 61-102,[3] for direct, induced, and willful infringement. Before the Court now are defendants' motions to dismiss, as well as the parties' various disputes over claim construction.

BACKGROUND

A diamond is a form of solid carbon with recognizable characteristics resulting from the carbon atoms being arranged in a particular crystalline structure. PGD Compl. ¶ 76. Diamonds form naturally deep within the earth's crust where carbon is subject to extremely high temperatures and pressures. Id. But what takes Mother Nature eons to produce can now be produced in a laboratory in a matter of days, using various techniques.

[2] Citations to the PGD complaint refer to the complaint in the Pure Grown Diamonds et al. action, 20-cv-189 (JSR), ECF No. 1 (Jan. 9, 2020).

[3] Citations to the Fenix complaint refer to the amended complaint in the Fenix action, 20-cv-200 (JSR), ECF No. 16 (Mar. 5, 2020).

These diamonds have the same "physical, chemical and optical qualities" as natural diamonds. Id. ¶ 77.

One such method for producing synthetic diamonds is called chemical vapor deposition (CVD). Broadly speaking, the CVD process begins with a tiny diamond "seed," which is "grown" into a full diamond by placing the seed in a "deposition chamber" and filling that chamber with energized hydrocarbon gases. Id. ¶ 78. CVD diamond production has existed for several decades, see '078 Patent, infra n.4, at 1:30-41, but the two patents-in-suit both describe particular methods that claim to improve upon the prior art for producing and purifying these diamonds.

The first patent-in-suit, the "'078 Patent,"[4] relates to a particular type of CVD production called microwave plasma CVD (MPCVD). In brief, MPCVD production involves placing a diamond seed into an enclosure, removing the ambient air from the enclosure, releasing hydrocarbon gases into the enclosure, and then turning those gases into plasma using microwaves, all while creating particular temperatures and pressure conditions around the diamond seed. See Pls.' Opening Claim Construction Br. at 3, No. 20-cv-189 (JSR), ECF No. 31 (Apr. 8, 2020).

[4] Apparatus and Method for Diamond Production, U.S. Patent No. US 6,858,078 (filed Nov. 6, 2002) (issued Feb. 22, 2005).

MPCVD diamond production was also known in the prior art, see '078 Patent at 1:42-51, but the '078 Patent describes a method for improving upon earlier production techniques in order to overcome a limitation inherent in those methods. Specifically, the prior methods caused a trade-off between diamond growth rate and quality, with attempts to produce high-quality "single crystal" diamonds at rates higher than about one micrometer per hour resulting in unwanted "twinned" diamonds or "polycrystalline" diamonds. '078 Patent at 1:52-59. These earlier methods also required that the gases in the chamber be maintained at low pressures. Id. at 1:59-61. The '078 Patent, in contrast, claims to improve upon the prior art by describing a method for producing single crystal MPCVD diamond at a higher growth rate. See Id. 1:64-67. As relevant to the instant lawsuit, this result is achieved by creating temperature and pressure conditions that fall within particular ranges and — importantly — by controlling the temperature gradients across the growth surface of the diamond seed such that they are less than 20°C. Id. 3:7-13.

The second patent-in-suit, the "'189 Patent,"[5] describes a method for repairing visual and other defects, such as

[5] Method of Making Enhanced CVD Diamond, U.S. Patent No. US RE41,189 (filed Jan. 30, 2009) (issued Apr. 6, 2010).

impurities and structural flaws, in lab-grown CVD diamonds. '189 Patent at 1:10-21, 43-49. For example, this method can be applied to CVD diamonds that appear "very dark" or even opaque after manufacture, in order to turn them clear so as to make them suitable for jewelry. See Pls.' Opening Claim Construction Br. at 6.

The claimed method involves encapsulating the diamond in an outer body, typically of graphite, and "annealing" it, i.e., applying very high temperatures and pressures within specific ranges. '189 Patent at 1:51-60; see Pls.' Opening Claim Construction Br. at 6-7. As with the '078 Patent, this invention builds upon existing knowledge. Here, it was known in the prior art that diamonds change their optical properties under high-pressure, high-temperature ("HPHT") conditions, but previous attempts to anneal CVD diamonds had worsened the optical defects in the diamonds or even converted them into graphite. '189 Patent at 2:29-40; see Pls.' Opening Claim Construction Br. at 6-7. The annealing method described in the '189 Patent avoids these earlier problems.

MOTIONS TO DISMISS

Defendants move to dismiss plaintiffs' infringement lawsuits on two grounds. First, PGD argues that the asserted claims are unpatentable under 35 U.S.C. § 101 because they are

natural phenomena.[6] Second, all defendants argue that plaintiffs' allegations in the respective complaints do not plausibly allege infringement.

A. Patentability Under 35 U.S.C. § 101

35 U.S.C. § 101 provides that "[w]hoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor . . . ." This statute, however, implicitly excepts "[l]aws of nature, natural phenomena, and abstract ideas," which are not patentable. *Mayo Collaborative Servs. v. Prometheus Labs., Inc.*, 566 U.S. 66, 70 (2012) (quoting *Diamond v. Diehr*, 450 U.S. 175, 185 (1981)).

In *Alice Corp. Pty. Ltd. v. CLS Bank Int'l*, 573 U.S. 208, 217-18 (2014), the Supreme Court set forth a two-step framework for determining whether this exception applies. At step one, the reviewing court must determine whether the patent's claims are "directed to" a natural phenomenon. *Id.* at 217. If so, then the court proceeds to step two, at which it searches the claim for "an 'inventive concept,' — *i.e.*, an element or combination of elements that is 'sufficient to ensure that the patent in practice amounts to significantly more than a patent upon the

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[6] Fenix does not raise this argument, but were the Court to declare the patents-in-suit ineligible on this ground, such a holding would also require dismissal with prejudice of the complaint against Fenix.

[ineligible concept] itself.'" Id. at 217-18 (quoting Mayo, 566 U.S. at 72-73) (internal quotation marks omitted) (alteration in original). If it does not contain such a concept, then the subject of the claim is patent-ineligible as a natural phenomenon or abstract idea. Further, when the pleadings are sufficient to resolve the issue, district courts may consider patent ineligibility under the doctrine of Mayo and Alice at the motion-to-dismiss stage. See Genetic Techs. Ltd. v. Merial L.L.C., 818 F.3d 1369, 1373 (Fed. Cir. 2016).

In this case, the Alice inquiry for both patents-in-suit ends at step one, as neither patent is "directed to" a natural phenomenon. The '078 Patent teaches a method for growing synthetic diamonds in a laboratory, under conditions different from those that produce natural diamonds and at a time scale far faster than that which occurs in the earth. Similarly, the '189 Patent describes a method for annealing diamonds in a manner that does not occur in nature. While both methods necessarily rely on principles of chemistry and physics, so, at some level, do most inventions. See Mayo, 566 U.S. at 71. For that reason, the Supreme Court has long recognized that "the application of the law of nature to a new and useful end" is a valid basis for a patent. Id. at 72 (quoting Funk Bros. Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 130 (1948)).

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Although it is sometimes challenging for courts to distinguish between laws of nature and applications thereof, the facts here clearly fall into the latter category. The analysis in Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 569 U.S. 576 (2013) is illustrative. There, the Supreme Court held that newly-isolated segments of naturally-occurring DNA are not patentable, but that segments of synthetically-created DNA are. The lab-grown diamonds at issue here are more like the synthetic DNA; both are facsimiles of natural substances, created from the same atomic building blocks but assembled through processes that do not occur in nature. The patents-in-suit are therefore not directed to a law of nature.

PGD's arguments are really not to the contrary. As to the '189 Patent, PGD argues that the tendency of diamond to change its optical properties under HPHT conditions is not only a natural phenomenon relating to the chemical properties of carbon, but also one already known since the 1970s. PGD's Mem. of Law in Supp. of Mot. to Dismiss Pls.' Compl., 20-cv-189 (JSR), ECF No. 29 (Mar. 30, 2020) at 5.[7] Against this backdrop, the only advance claimed by the '189 patent is the application of this same method to CVD diamond, a claim which is tantamount

[7] See also Annealing Type IB or Mixed Type IB-IA Natural Diamond Crystal, U.S. Patent No. 4,124,690 (filed Dec. 2, 1977).

to application of a natural law as synthetic and natural diamonds have identical chemical properties. Id. at 10. Similarly, as to the '078 Patent, PGD argues that the Patent merely directs the application of a known natural law — the tendency of single-crystal diamond to grow more efficiently under uniform temperature conditions — to a method known in the prior art. See id. at 14-15.

These points, however, sound more in "obviousness" than they do in eligibility, and such objections are not currently before the Court. PGD cannot seriously argue that plaintiffs are attempting to patent the diamond growth process that occurs in the earth's crust; the true nature of PGD's argument is that plaintiffs' patents represent an insufficient advance over the prior art. But such disputes are properly reserved for a later stage of the litigation.[8]

B. Plausibility of Pleadings

Next, all defendants move to dismiss under Fed. R. Civ. P. 12(b)(6), arguing that plaintiffs' complaints in the two

[8] The instant case is accordingly distinguished from Am. Axle & Mfg., Inc. v. Neapco Holdings LLC, 939 F.3d 1355 (Fed. Cir. 2019). There, the court held a patent ineligible under § 101 because the only claimed advance was the application of a mathematical equation called Hooke's law to a manufacturing process known in the prior art. But this appeal occurred at the summary judgment stage, when the court had the benefit of a record outside the pleadings in determining that the patent claimed nothing more than application of this law of nature.

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respective actions do not plausibly allege infringement. To survive a motion to dismiss, a complaint must allege "enough facts to state a claim to relief that is plausible on its face." Bell Atl. Corp. v. Twombly, 550 U.S. 544, 570 (2007). If a complaint "pleads facts that are 'merely consistent with' a defendant's liability, it 'stops short of the line between possibility and plausibility of entitlement to relief.'" Ashcroft v. Iqbal, 556 U.S. 662, 678 (2009) (quoting Twombly, 550 U.S. at 557) (internal quotation marks omitted).

To make a claim for direct infringement, plaintiffs must allege that defendants' methods "meet[] every claim limitation either literally or under the doctrine of equivalents." Pfizer, Inc. v. Teva Pharm., USA, Inc., 429 F.3d 1364, 1376 (Fed. Cir. 2005). Plaintiffs' complaints in both actions do so. The complaints plead, "upon information and belief," that defendants are manufacturing, importing, and/or selling high-quality "Type IIa" diamonds produced through the MPCVD process. PGD Compl. ¶¶ 81-86, 87-91; Fenix Compl. ¶¶ 51-60. From just this allegation, plaintiffs infer that defendants' diamonds must have been grown and/or annealed using the processes patented in the '078 and '189 Patents. PGD Compl. ¶¶ 98-100, 125-26; Fenix Compl. ¶¶ 65-67, 88-89. Although this factual basis is somewhat limited, the Court finds it minimally sufficient to state a claim for direct infringement. Based on the allegations that defendants' diamonds

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could not be of the type and quality claimed unless produced through infringing methods, see, e.g., PGD Compl. ¶¶ 88-90, 123; Fenix Compl. ¶¶ 53-57, 87, it is at least plausible that defendants are directly infringing the patents-in-suit.

Defendants' reliance on Artrip v. Ball Corp., 735 Fed. App'x 708 (Fed Cir. 2018) does not persuade the Court otherwise. There, the Federal Circuit affirmed the dismissal of a complaint that alleged infringement with nothing more than "broad functional language" and that did not specifically identify the defendant's purportedly infringing products. Id. at 714-15. But the complaint's failure there was far more egregious than anything at issue here. Specifically, the plaintiff in that case had already taken two opportunities to amend the complaint and had already been provided with limited discovery. Despite all of that, the complaint at issue was only twenty-three paragraphs in length. See Third Amended Complaint, No. 1:14-cv-14 (JPJ) (PMS), ECF No. 111 (W.D. Va. Sept. 14, 2017). Plaintiffs here, with less information than the plaintiff in Artrip, have nonetheless advanced more plausible and complete allegations.

Plaintiffs have also satisfactorily alleged the scienter element of induced and willful infringement. "[I]nduced infringement under [35 U.S.C.] § 271(b) requires knowledge that the induced acts constitute patent infringement." Global-Tech Appliances, Inc. v. SEB S.A., 563 U.S. 754, 766 (2011).

Similarly, a claim for willful infringement requires a violation that is "willful, wanton, malicious, bad-faith, deliberate, [or] consciously wrongful." See Halo Elecs., Inc. v. Pulse Elecs., Inc., 136 S. Ct. 1923, 1932 (2016). Here, plaintiffs rely on the general notoriety of their patents in the relevant field, as well as, in the case of PGD, the fact that its Chief Technical Officer was himself the named inventor on at least seven diamond patents. See PGD Compl. ¶¶ 111, 135; Fenix Compl. ¶¶ 75-76, 96. Although something of a close call, the Court finds this sufficient at this stage to raise a plausible inference that defendants knew of the patents-in-suit. The motions to dismiss for failure to state a claim are accordingly denied.

CLAIM CONSTRUCTIONS

Because plaintiffs' complaints survive defendants' motions to dismiss, the Court must next consider the parties' motions for construction of several terms in the relevant claims of the '078 and '189 Patents pursuant to Markman v. Westview Instruments, Inc., 517 U.S. 370 (1996). Specifically, after the parties had extensively briefed their respective positions, the Court conducted a lengthy "Markman" hearing on April 24, 2020. See Transcript, Apr. 24, 2020 (forthcoming on ECF).

Specifically, the claim construction issues below relate to two independent claims of the '078 Patent. Claim 1 recites:

> A method for diamond production, comprising: controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20°C.; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr.

'078 Patent at 14:64-15:4. Claim 12 recites:

> A method for diamond production, comprising: controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20°C.; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a temperature of 900-1400°C.

Id. at 15:31-37.

There are further claim construction questions relating to Claim 1 of the '189 Patent, which recites:

> A method to improve the optical clarity of CVD diamond where the CVD diamond is single crystal CVD diamond, by raising the CVD diamond to a set temperature of at least 1500°C. and a pressure of at least 4.0 GPA outside of the diamond stable phase.

'189 Patent at 4:10-14.

In construing these claims, the Court must give their terms the meaning understood by a person of ordinary skill in the art at the time of invention. Phillips v. AWH Corp., 415 F.3d 1303, 1313 (Fed. Cir. 2005) (en banc). "Properly viewed, the 'ordinary meaning' of a claim term is its meaning to the ordinary artisan after reading the entire patent." Id. at 1321.

A. Claim Constructions for the '078 Patent

1. *"controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20°C." (Claims 1 and 12)*

Plaintiffs' Construction	**PGD's Construction**	**Fenix's Construction**
no construction needed (plain and ordinary meaning)	plain and ordinary meaning, that is, "using temperatures measured at the middle and an edge of a growth surface of the diamond to maintain all temperature gradients across the growth surface at less than 20°C."	[same as PGD's]

The term at issue relates to a key advance claimed in the '078 Patent — a method for controlling not just the temperature of particular spots on the growth surface of a CVD diamond, but all temperature gradients across the growth surface, i.e., the differences in temperature between any one spot on the growth surface and any other. See '078 Patent at 7:10-11. All three parties purport to give this term its "ordinary" meaning, and plaintiffs argue that no construction is needed at all. But the defendants in both actions advance a (common) construction that limits the term in three ways: (1) to refer to one particular set of temperature gradients ("temperatures measured at the middle and an edge of a growth surface of the diamond"); (2) to require that those particular gradients be "us[ed] . . . to maintain all temperature gradients" at less than 20°C.; and (3)

to clarify that those temperature gradients must be "maintain[ed]" below the 20° level.

As to the first issue, defendants' proposed limitation to the particular set of temperature gradients between the middle and the edge of the growth surface is expressly contradicted by the language of the Patent. See Merck & Co., Inc. v. Teva Pharm. USA, Inc., 347 F.3d 1367, 1371 (Fed. Cir. 2003) ("A fundamental rule of claim construction is that terms in a patent document are construed with the meaning with which they are presented in the patent document.").

Claims 1 and 12 refer to "all temperature gradients across the growth surface," not merely those measured between the middle and the edge. Concededly, the Patent teaches that large temperature variations "typically . . . occur between the edges and the middle of the growth surface of the diamond." '078 Patent at 7:10-13; see also id. at 7:13-15, 19-23, 41-46. This would suggest that, in most cases, if the middle-edge gradient is less than 20°C., then all of the gradients will be. But the language of this explanation is not nearly so categorical as defendants portray it to be. The Patent does not preclude the possibility that the temperature gradient between two points on the edge of the growth surface could, in rare cases, exceed that between the middle and the edge. In that case, the claimed method still teaches that the larger gradient must be below

20°C. The Court accordingly rejects defendants' limitation to "temperatures measured at the middle and an edge of a growth surface of the diamond."

The Court also agrees with plaintiffs that the "using" limitation must be rejected. Defendants' construction suggests that the middle-edge gradients are the only inputs used in the method to maintain appropriate temperatures around the diamond seed. Defendants point to certain of the Patent's descriptions of the method, which suggest that it "uses" these temperature measurements to control the gradient. E.g. '078 Patent at 2:45-52 ("In accordance with another embodiment of the present invention, a method for producing diamond includes . . . controlling temperature of the growth surface based upon the temperature measurements . . . ."); id. at 6:65-7:2. But other language in the Patent appears to define "controlling" more broadly, mentioning that other inputs are also "used" to control the gradients. Id. at 6:55-65 ("The ability to control all of the temperature gradients across the growth surface of the diamond is influenced by several factors, including the heat sinking capability of the stage, the positioning of the top surface of the diamond in the plasma, the uniformity of the

plasma that the growth surface of the diamond is subjected to, . . . [etc.]").[9]

The final issue that defendants raise with respect to this term is that the proper construction must include a temporal limitation, i.e., that the that the temperature gradients on the growth surface must be "maintained" at less than 20°C. during the growth process, rather than achieved for a mere instant. The Court agrees. The Patent's description of the method repeatedly suggests that the gradients must be maintained below this threshold for substantially the entire growth process in order to achieve the desired single-crystal diamond growth. Not only does the Patent explain that the growth process is suspended if the gradients cannot be sufficiently controlled, id. at 11:20-24, but the Patent itself even uses the word "maintain" in this context, id. at 11:15-16 ("The main process controller controls the temperature by maintaining thermal gradients of less than 20°C. across the growth surface.") (emphasis supplied).[10] Because

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[9] The heart of defendants' objection here is that plaintiffs' construction would allow "the asserted claims [to] be infringed without the alleged infringer even trying to achieve temperature gradients less than 20°C." But the word "control" in Claims 1 and 12 is plainly qualified by the other factors quoted above.

[10] So, too, do plaintiffs' complaints in both actions. PGD Compl. ¶ 68 ("The '078 Patent teaches a method for producing MPCVD diamonds using a faster growth rate, moderate pressures within the deposition chamber, and with a particular temperature gradient to be maintained during diamond growth.") (emphasis supplied); Fenix Compl. ¶ 37 (same quote).

the Court's construction must "stay[] true to the claim language and . . . align[] with the patent's description of the invention," Trs. of Columbia Univ. v. Symantec Corp., 811 F.3d 1359, 1366 (Fed. Cir. 2016) (citation omitted), the Court agrees that a temporal limitation must be added to the construction of this term.

For these reasons, the Court adopts the following construction for the term at issue: "controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are maintained at less than 20°C."

2. "the growth surface" (Claims 1 and 12)

Plaintiffs' Construction	**PGD's Construction**	**Fenix's Construction**
plain and ordinary meaning, that is, "the diamond seed surface or diamond surface that is closest to the plasma, upon which single-crystal growth primarily occurs as the diamond grows"	plain and ordinary meaning, no construction necessary	plain and ordinary meaning, that is, "the surface upon which diamond growth is occurring"

The parties next seek construction of "the growth surface." The difference between their positions is minor; all parties appear to agree that a skilled artisan would read this term to refer to the surface on which diamond growth is occurring at a given moment in the MPCVD process. At the outset, that is, the

growth surface is the exterior surface of the diamond seed, but the growth surface then shifts outward as the hydrocarbon gases accrue onto the seed to form new diamond. See '078 Patent at 4:64-67.

As to the defendants' competing proposals, although the Court may accord simple words their ordinary meaning, Chef Am., Inc. v. Lamb-Weston, Inc., 358 F.3d 1371, 1373 (Fed. Cir. 2004), Fenix's proposal more accurately captures the fact that the area constituting the growth surface changes over time.

Plaintiffs' proposed construction, on the other hand, would wrongly restrict the term to include only surface area where single-crystal diamond is growing. The Patent notes that, even where its method of growing single-crystal diamond is followed, small amounts of polycrystalline diamond will nonetheless grow in localized places on the diamond. See '078 Patent at 13:66-14:1. For two reasons, such areas should still be included within the definition of "growth surface." First, where the term is used in the Patent, the surrounding context generally does not require such a distinction. E.g., id. at 2:12-65; 4:56-67; 7:5-23. Since the Patent uses the term to refer to the entire surface where hydrocarbon gases are accruing into new diamond, the claim construction must impart the same meaning. See Merck & Co., 347 F.3d at 1371. Second, the Patent notes that the MPCVD method, if applied with different parameters, can also used to

produce synthetic polycrystalline diamonds. '078 Patent at 13:25-26. An artisan knowledgeable in this field would therefore also recognize the term "growth surface" to have the same meaning described above in a process intended to produce polycrystalline diamond. The construction of the term "growth surface" must therefore not exclude polycrystalline growth.

The Court accordingly adopts Fenix's proposed construction of this term.

3. *"growing single-crystal diamond . . . on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr" (Claim 1)*

Plaintiffs' Construction	**PGD's Construction**	**Fenix's Construction**
plain and ordinary meaning, no construction needed	plain and ordinary meaning, that is, "growing single-crystal diamond ... on the growth surface, which is maintained at a growth temperature and located in a deposition chamber with an atmosphere maintained at a pressure of at least 130 torr"	[same as PGD's]

"growing single-crystal diamond . . . on the growth surface at a temperature of 900-1400° C" (Claim 12)

Plaintiffs' Construction	**PGD's Construction**	**Fenix's Construction**
plain and ordinary meaning, no construction needed	plain and ordinary meaning, that is, "growing single-crystal diamond ...	[same as PGD's]

	on the growth surface, which is maintained at a temperature of 900–1400° C"	

Turning next to two similar phrases that appear in Claim 1 and Claim 12 respectively, plaintiffs argue that no construction of these terms is necessary, while defendants jointly seek a construction that limits the terms in two ways. The first proposed limiting construction clarifies that the stated temperature conditions refer to the temperature of the growth surface, rather than the temperature of the deposition chamber as a whole. The second proposed limitation is to clarify that the temperature and pressure conditions referenced in Claims 1 and 12 must be "maintained" throughout the growth process.

The Court largely agrees with defendants as to both issues. With respect to the first, the specification of the '078 Patent refers repeatedly to the temperature on the growth surface, rather than the temperature inside the deposition chamber as a whole. E.g. '078 Patent at Abstract ("[A] . . . device positioned to measure temperature of the diamond across the growth surface . . ."); id. at 6:48-50 ("The main process controller . . . controls the temperatures of the growth surface . . . ."); id. at 11:1-3 ("[T]he temperature of the growth surface of the diamond, either the diamond seed or grown diamond, is measured."). It is obvious from this context that

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the relevant temperature for purposes of the patented method is the temperature of the growth surface. Reading the "claim language 'in view of the specification, of which [the claims] are a part,'" Guardian Media Techs., Inc. v. Amazon.com, Inc., No. 13-cv-8369 (PSG) (PLAx), 2015 WL 12656953, at *4 (C.D. Cal. Apr. 1, 2015) (quoting Phillips, 415 F.3d at 1315) (alteration in original), the Court adopts the defendants' construction with respect to this issue.

As to the second issue — whether the stated temperature and pressure conditions must be "maintained" throughout the growth process — this issue involves many of the same disputes as discussed above in the context of the temperature gradient term. For similar reasons, the Court agrees with defendants that plaintiffs' construction wrongly suggests that a method that imposes the specified temperatures and pressures even momentarily would infringe the '078 Patent. Such a construction would be improper because the '078 Patent expressly distinguishes the claimed method from prior art CVD processes that utilize lower temperatures and pressures to synthesize diamond at a lower growth rate. See '078 Patent at 1:42-61. When the "description of the invention describes a feature . . . and criticizes other products . . . that lack that same feature, this operates as a clear disavowal of these other products." Astrazeneca AB v. Mut. Pharm. Co., 384 F.3d 1333, 1340 (Fed Cir.

2004). The clear implication of this contrasting description is that the stated temperatures and pressures must be applied during a substantial portion of the growth process.

Plaintiffs respond that the word "maintain" means that these temperature and pressure conditions must be achieved for the entirety of the growth process, and not just a majority or even substantially all of it. Plaintiffs note that both Claim 1 and Claim 12 begin with the transitional word "comprising," which at least one other court has read to imply that a subsequent list of steps was not intended to be exhaustive. See Invitrogen Corp. v. Biocrest Mfg., L.P., 327 F.3d 1364, 1366-68 (Fed. Cir. 2003). The Court agrees that the construction of this term should not exclude brief introductory and concluding steps that occur outside of the stated temperature and pressure ranges. "Maintain," therefore, is too restrictive of a word in this context,[11] and the Court will substitute the slightly broader word "set."

For these reasons, the following constructions are adopted: for the term in Claim 1, "growing single-crystal diamond ... on the growth surface, which is set at a growth temperature and

[11] Plaintiffs raised this same argument above in the context of the temperature gradient term. But there, as noted, the Court is persuaded that the term "maintain" is appropriate because the '078 Patent itself — as well as plaintiffs' complaints in these actions — use the word "maintain" in the relevant context.

located in a deposition chamber with an atmosphere set at a pressure of at least 130 torr"; and for the term in Claim 12, "growing single-crystal diamond ... on the growth surface, which is set at a temperature of 900-1400°C."

B. Claim Constructions for the '189 Patent

1. "to improve the optical clarity of [a] CVD diamond"

Plaintiffs' Construction	PGD's Construction	Fenix's Construction
plain and ordinary meaning, that is, "to decrease the opacity of CVD diamond"	This phrase is non-limiting. In the alternative, plain and ordinary meaning, that is, "to make CVD diamond appear more clear"	This phrase is non-limiting. If limiting, then the phrase is indefinite.

The threshold (and definitive) dispute with respect to this term is whether it is limiting. The Court agrees with defendants that it is not. The contested phrase appears as part of Claim 1's preamble, i.e., it describes the purpose or intended use of the method, rather than a step of the method. The Federal Circuit "ha[s] long ruled that 'a preamble is not limiting where a patentee defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention.'" Arctic Cat Inc. v. GEP Power Prods., 919 F.3d 1320, 1328 (Fed. Cir. 2019) (quoting Catalina Mktg. Int'l v. Coolsavings.com, Inc., 289 F.3d 801, 808 (Fed. Cir. 2002)) (internal quotation marks omitted). Application of

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this canon of construction would therefore suggest that the instant term is not limiting.

Plaintiffs respond that the phrase is limiting because it provides the antecedent for the later use of the phrase "CVD diamond" throughout the claim; reading the claim with the preamble included therefore is ungrammatical. Pls.' Rebuttal Claim Construction Br. at 18, 20-cv-189 (JSR), ECF No. 37 (Apr. 17, 2020). But this is just a product of the particular wording chosen by the drafter of the Patent; that is, the phrase could have been defined outside of the preamble without affecting the substance of the claim. See Am. Med. Sys. v. Biolitec, Inc., 618 F.3d 1354, 1359 (Fed. Cir. 2010) ("[T]he preamble has no separate limiting effect if, for example, 'the preamble merely gives a descriptive name to the set of limitations in the body of the claim that completely set forth the invention.'") (quoting IMS Tech., Inc. v. Haas Automation, Inc., 206 F.3d 1422, 1434 (Fed. Cir. 2000)). The Court accordingly finds plaintiffs' argument unpersuasive, and this term will not be given limiting effect.

2. *"by raising the CVD diamond to a set temperature of at least 1500°C. and a pressure of at least 4.0 GPA outside of the diamond stable phase"*

Plaintiffs' Construction	**PGD's Construction**	**Fenix's Construction**
"by raising the CVD diamond to a set temperature of at	[same as plaintiffs']	[same as plaintiffs']

least 1500° C. and a pressure of at least 4.0 gigapascals (GPA), where the temperature and the pressure are together outside of the diamond stable phase"		

The parties have stipulated to the above construction. Although "the Court is not required to adopt a construction of a term, even if the parties have stipulated to it," Lam Research Corp. v. Schunk Semiconductor, 65 F. Supp. 3d 863, 871 (N.D. Cal. 2014) (emphasis and citation omitted), here the Court agrees that a skilled artisan would give this term its stipulated meaning.

The phrase "diamond stable phase" refers to temperature-pressure phase diagram of carbon, which appears at page 19 of defendant PGD's opening claim construction brief, 20-cv-189 (JSR), ECF No. 32 (Apr. 8, 2020). This diagram depicts that, depending on the temperature and pressure that it is subject to, elemental carbon will exist as either diamond, graphite, or a liquid. The "diamond stable phase" is the set of temperatures and pressures under which carbon exists as diamond. The chart also depicts a boundary, the "diamond-graphite boundary," between the diamond stable phase and the graphite stable phase, i.e., the temperatures and pressures under which carbon exists as graphite.

What necessitates construction here derives from the fact that the claim is poorly drafted. Read literally, the claim would refer to CVD diamond subject to (1) a temperature over 1500°C and (2) a pressure of at least 4 gigapascals "outside the diamond stable phase," i.e., at least 4 gigapascals below the diamond-graphite boundary for a given temperature.

But that reading is nonsensical, both as a scientific matter and from the context of the Patent. The temperatures and pressures described in the Patent's example, see '189 Patent at 3:16-4:8, are inconsistent with this literal reading but consistent with the stipulated construction. A skilled artisan, therefore, would read the claim in its context to have this stipulated meaning, i.e., CVD diamond subject to (1) a temperature over 1500 degrees C, (2) a pressure of at least 4 gigapascals, and (3) a temperature and pressure combination that falls below the diamond-graphite boundary. The Court accordingly adopts the parties' construction.

C. Claim Constructions for Both Patents

1. *"single-crystal diamond" ('078) and "single crystal CVD diamond" ('189)*

Plaintiffs' Construction	**PGD's Construction**	**Fenix's Construction**
plain and ordinary meaning, that is, "a stand alone diamond [made by chemical vapor deposition] having a	plain and ordinary meaning, that is, "a stand alone diamond [made by chemical vapor deposition] having insubstantial	plain and ordinary meaning, that is, "a stand alone diamond [made by chemical vapor deposition]

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substantially single-crystal structure”	non-monocrystalline growth”	having insubstantial polycrystallinity”

Finally, the parties seek construction of the term “single-crystal diamond” in the ‘078 Patent and the equivalently-used term “single crystal CVD diamond” in the ‘189 Patent. The parties agree that a “single-crystal” diamond is a stand-alone diamond that has a primarily single-crystal, as opposed to polycrystalline, structure. They also agree that a diamond can still be deemed single-crystal even if it contains small and localized amounts of polycrystallinity or other impurities, such as graphite, twinned diamond, or diamond-like carbon, in its atomic structure. See ‘078 Patent at 13:66-14:1; see also id. at 1:38-40; 5:5-9; 13:25-27. But they disagree about how to describe the amount of impurity that is acceptable.

There is a small substantive difference between the competing constructions, as plaintiffs’ construction appears somewhat broader than defendants’. Many of plaintiffs’ arguments in particular, however, focus not on the accuracy of these constructions but on which descriptions a lay jury would most readily understand. See Pls.’ Opening Claim Construction Br. at 21-23. The Court need not consider these arguments. A court’s mandate in a Markman hearing is to give a patent’s terms the meaning that a skilled artisan would accord to them, not a meaning that a lay jury would find accessible. See Phillips, 415

F.3d at 1313. The Court is therefore unpersuaded by plaintiffs' arguments that defendants' constructions are confusingly worded.

As to the substantive differences between the parties, the Court agrees that plaintiffs' construction is too broad. The '078 Patent in two places uses the term "substantially single-crystal diamond," '078 Patent at 16:64-65; 18:13-14, thereby distinguishing that term from "single crystal diamond." Plaintiffs' construction would include both, rendering the distinction in the Patent meaningless.

Between the two defendant groups' constructions, PGD's correctly captures that polycrystalline diamond is not the only type of non-single crystal growth. (It is not clear how Fenix's construction, for example, would categorize an otherwise-single crystal diamond containing more than an insubstantial amount of twinned diamond or diamond-like carbon.) For that reason, the Court adopts PGD's construction.

CONCLUSION

For the foregoing reasons, defendants' motions to dismiss are denied in their entirety, and the Court adopts the claim constructions stated above.

SO ORDERED

Dated: New York, NY
May 8, 2020

United States District Judge

US006858078B2

(12) **United States Patent**
Hemley et al.

(10) **Patent No.: US 6,858,078 B2**
(45) **Date of Patent: Feb. 22, 2005**

(54) **APPARATUS AND METHOD FOR DIAMOND PRODUCTION**

(75) Inventors: **Russell J. Hemley**, Chevy Chase, MD (US); **Ho-kwang Mao**, Washington, DC (US); **Chih-shiue Yan**, Washington, DC (US); **Yogesh K. Vohra**, Birmingham, AL (US)

(73) Assignee: **Carnegie Institution of Washington**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 155 days.

(21) Appl. No.: **10/288,499**

(22) Filed: **Nov. 6, 2002**

(65) **Prior Publication Data**

US 2003/0084839 A1 May 8, 2003

Related U.S. Application Data

(60) Provisional application No. 60/331,073, filed on Nov. 7, 2001.

(51) **Int. Cl.**[7] **C30B 25/02**; C30B 25/12

(52) **U.S. Cl.** **117/68**; 117/98; 117/103; 117/924; 118/723; 118/725; 423/446; 427/577

(58) **Field of Search** 117/68, 98, 103, 117/924, 84; 118/723, 725; 423/446; 427/577

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(List continued on next page.)

Primary Examiner—Felisa Hiteshew
(74) *Attorney, Agent, or Firm*—Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An apparatus for producing diamond in a deposition chamber including a heat-sinking holder for holding a diamond and for making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, a noncontact temperature measurement device positioned to measure temperature of the diamond across the growth surface of the diamond and a main process controller for receiving a temperature measurement from the noncontact temperature measurement device and controlling temperature of the growth surface such that all temperature gradients across the growth surface are less than 20° C. The method for producing diamond includes positioning diamond in a holder such that a thermal contact is made with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, measuring temperature of the growth surface of the diamond to generate temperature measurements, controlling temperature of the growth surface based upon the temperature measurements, and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface, wherein a growth rate of the diamond is greater than 1 micrometer per hour.

64 Claims, 8 Drawing Sheets

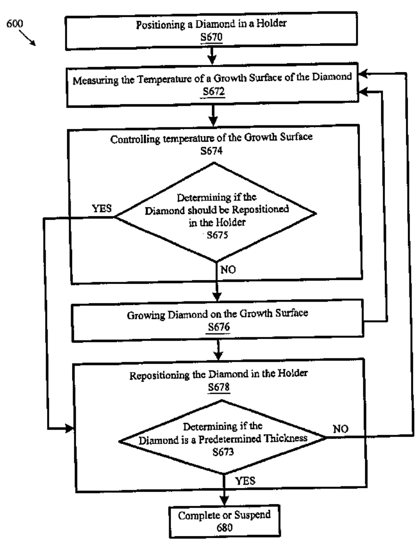

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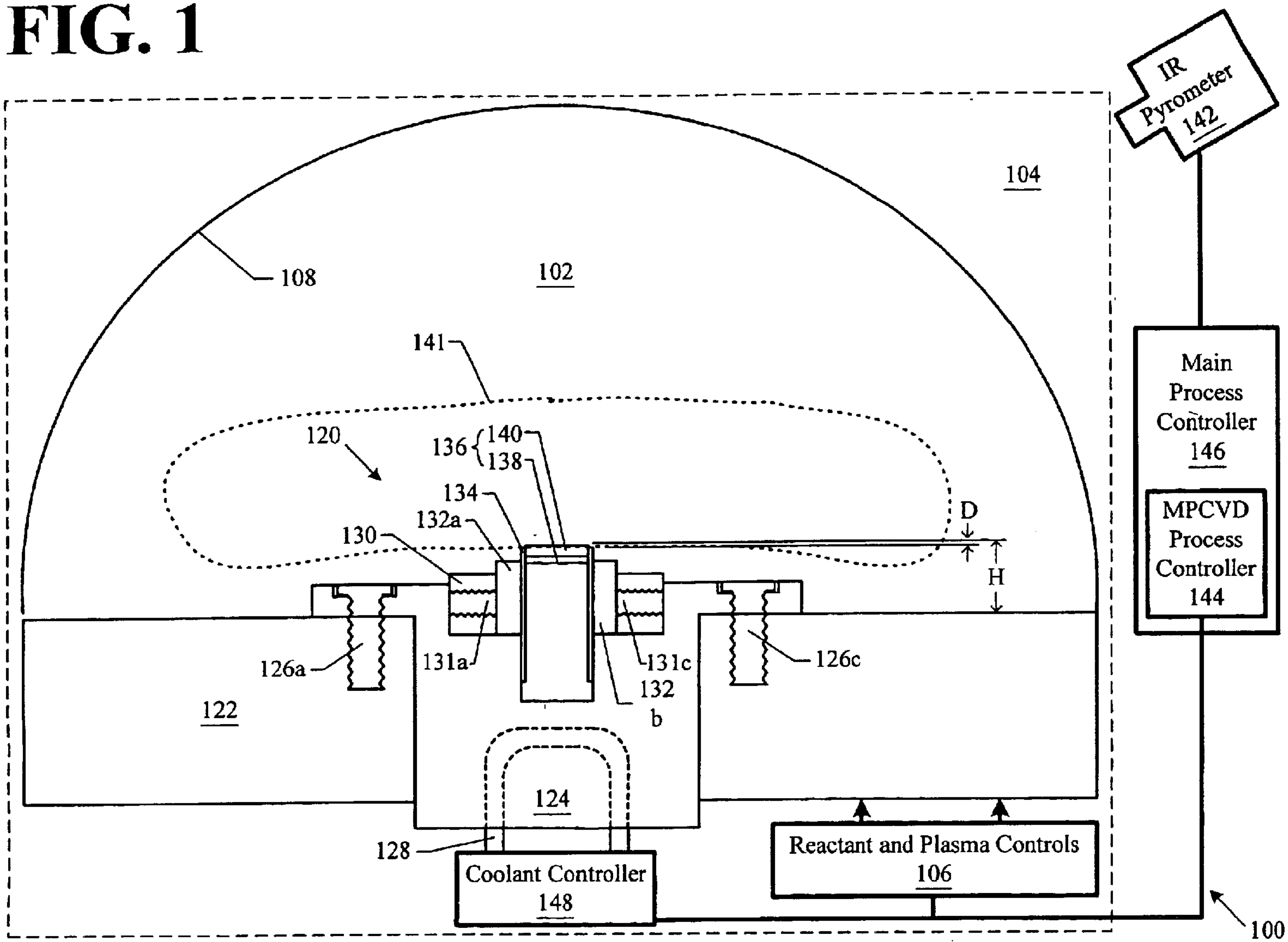
FIG. 1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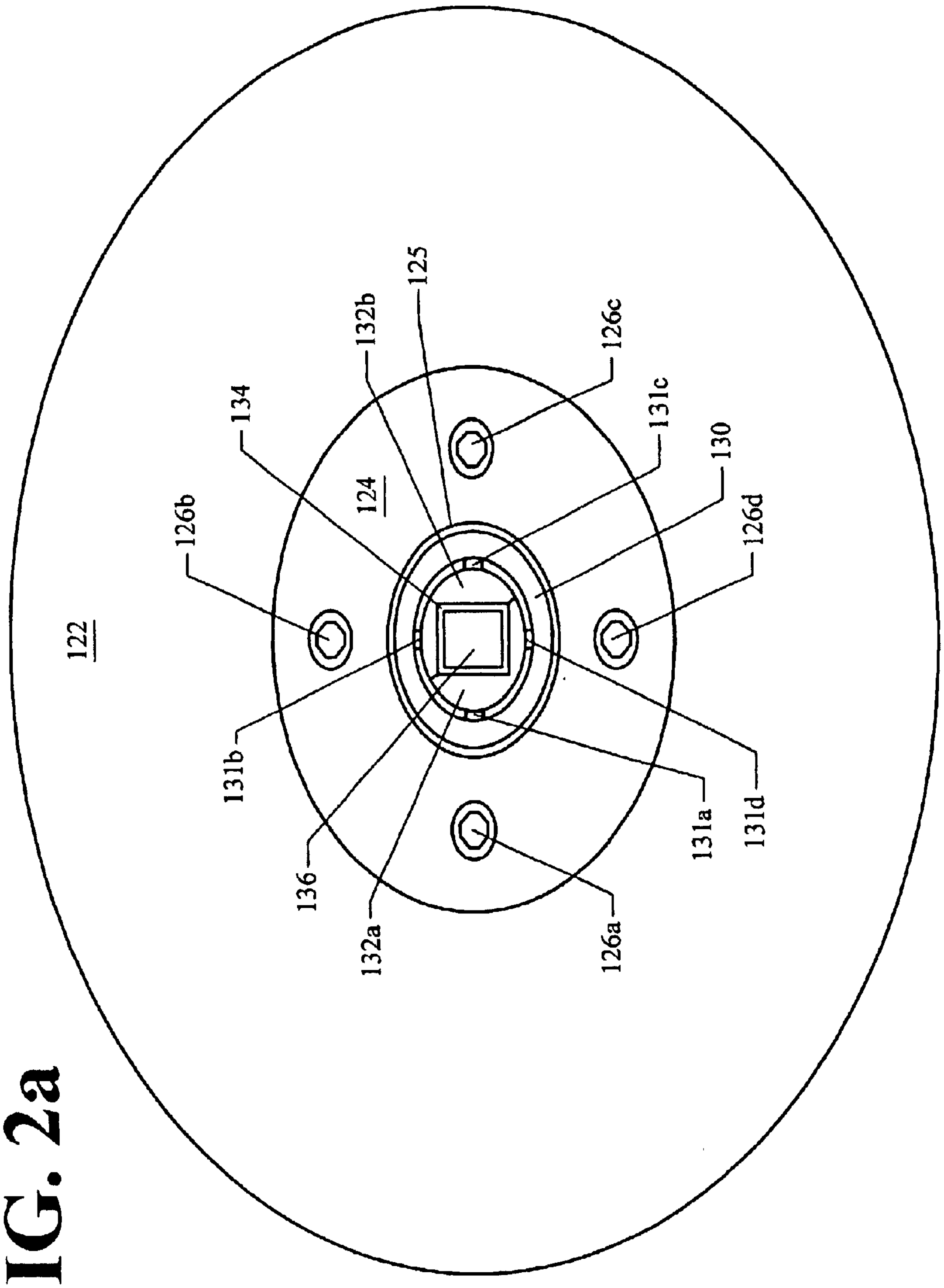
104
108
102
141
120
136
140
138
134
132a
130
D
H
126a
131a
131c
132
b
126c
122
124
128
Coolant Controller 148
Reactant and Plasma Controls 106
Main Process Controller 146
MPCVD Process Controller 144
100


122
124
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126b
126c
126d
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131a
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131c
131d
132a
132b
134
136

FIG. 2a

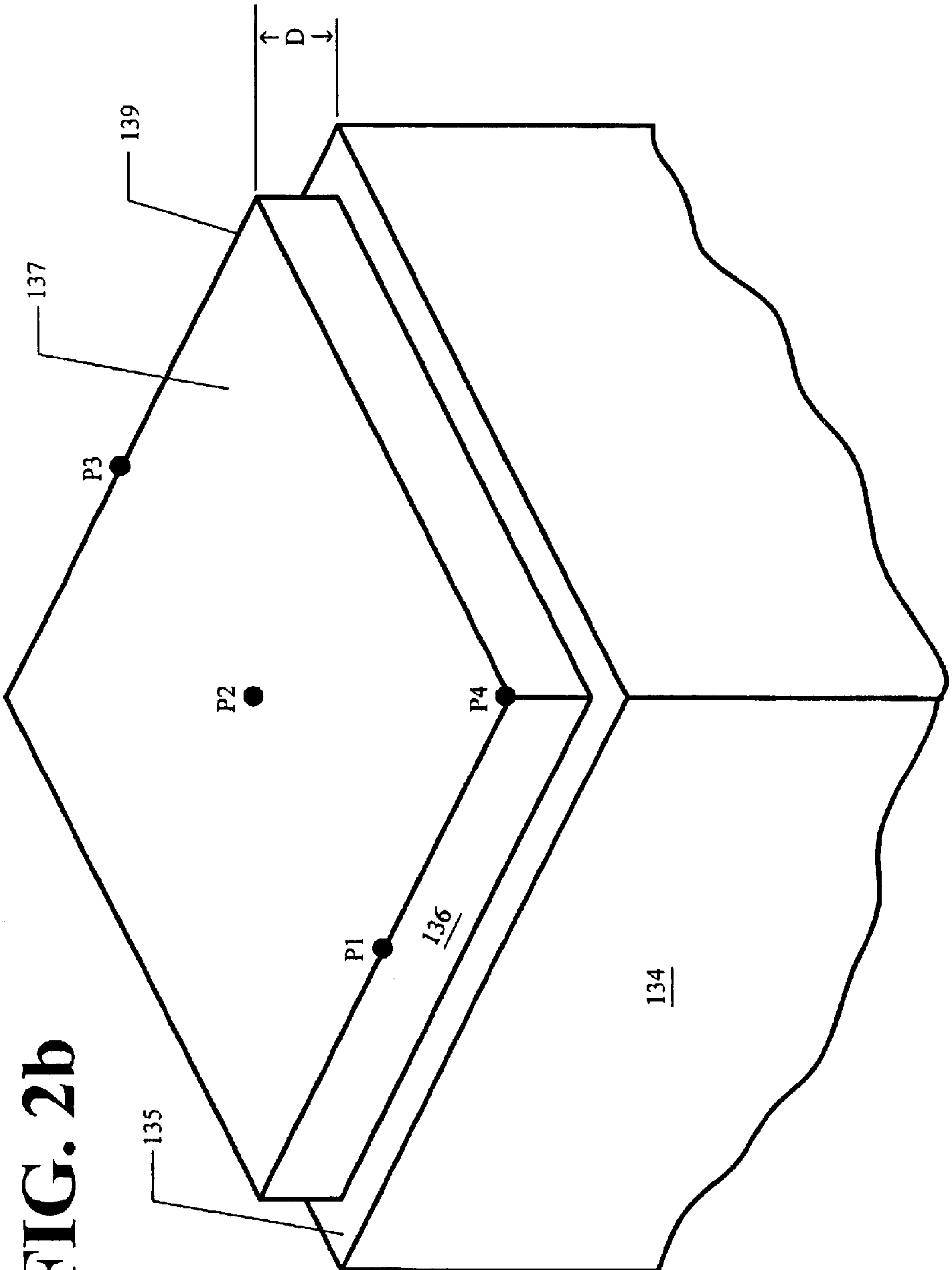
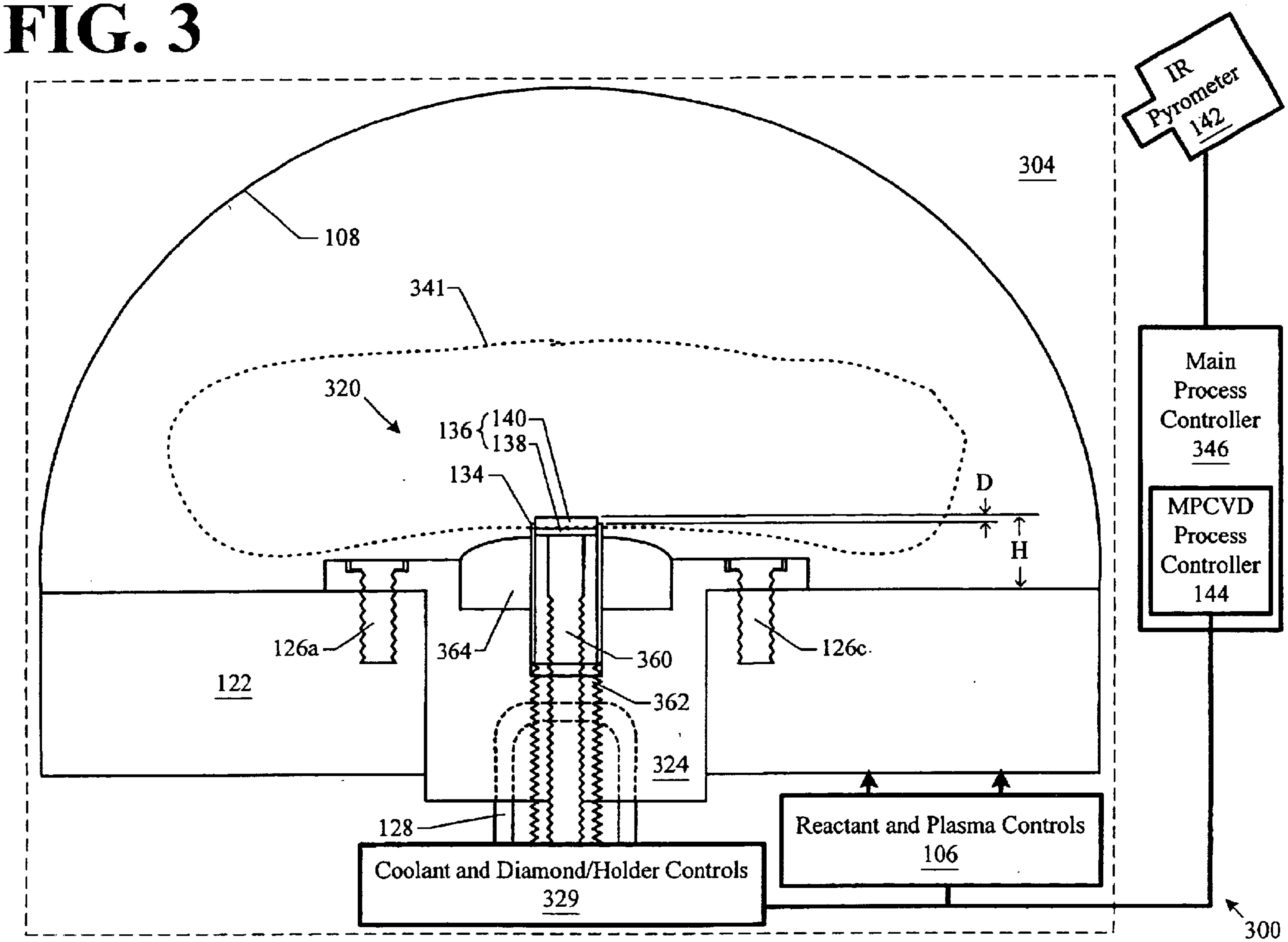


FIG. 2b

FIG. 3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108
341
320
136
140
138
134
D
H
Main Process Controller 346
MPCVD Process Controller 144
126a
364
360
126c
122
362
324
128
Coolant and Diamond/Holder Controls 329
Reactant and Plasma Controls 106
300

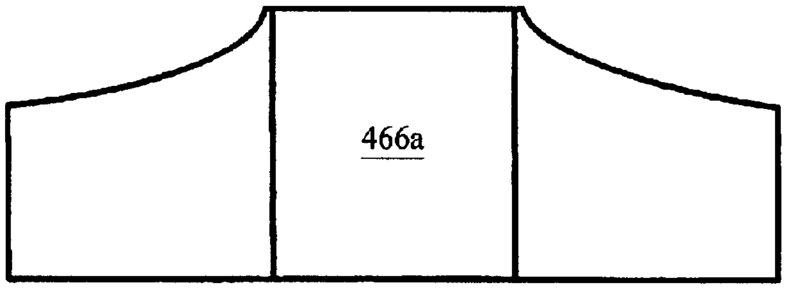


FIG. 4a

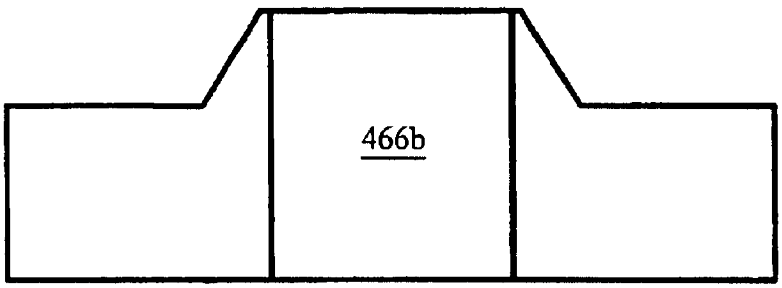


FIG. 4b

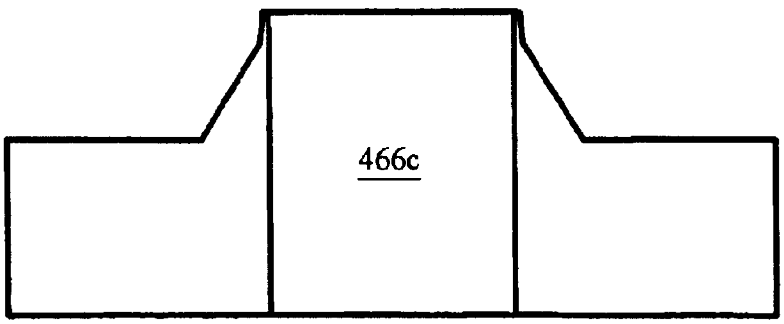
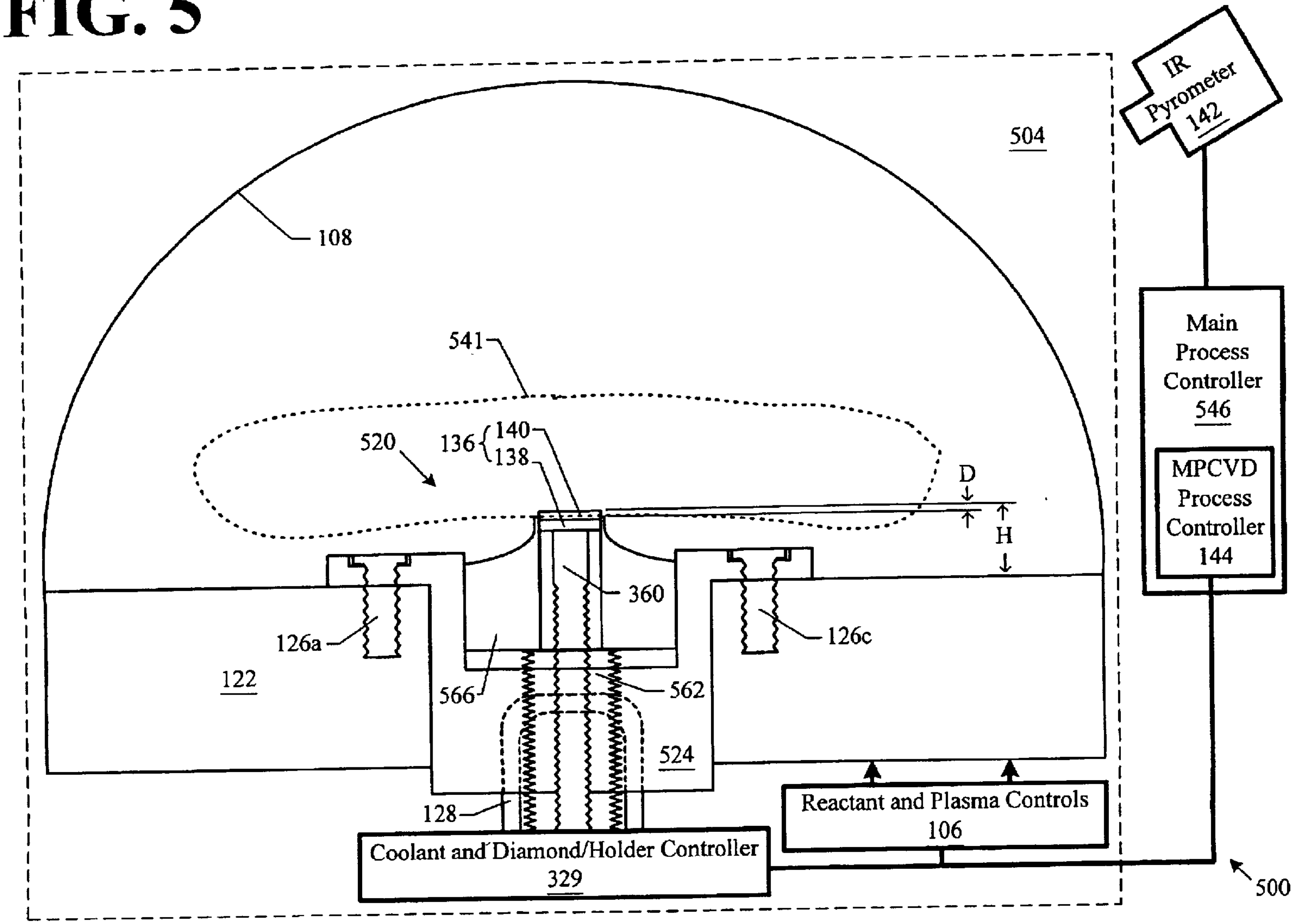


FIG. 4c

FIG. 5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Pyrometer
142
504
108
Main
Process
Controller
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MPCVD
Process
Controller
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541
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140
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H
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566
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524
128
Reactant and Plasma Controls
106
Coolant and Diamond/Holder Controller
329
500

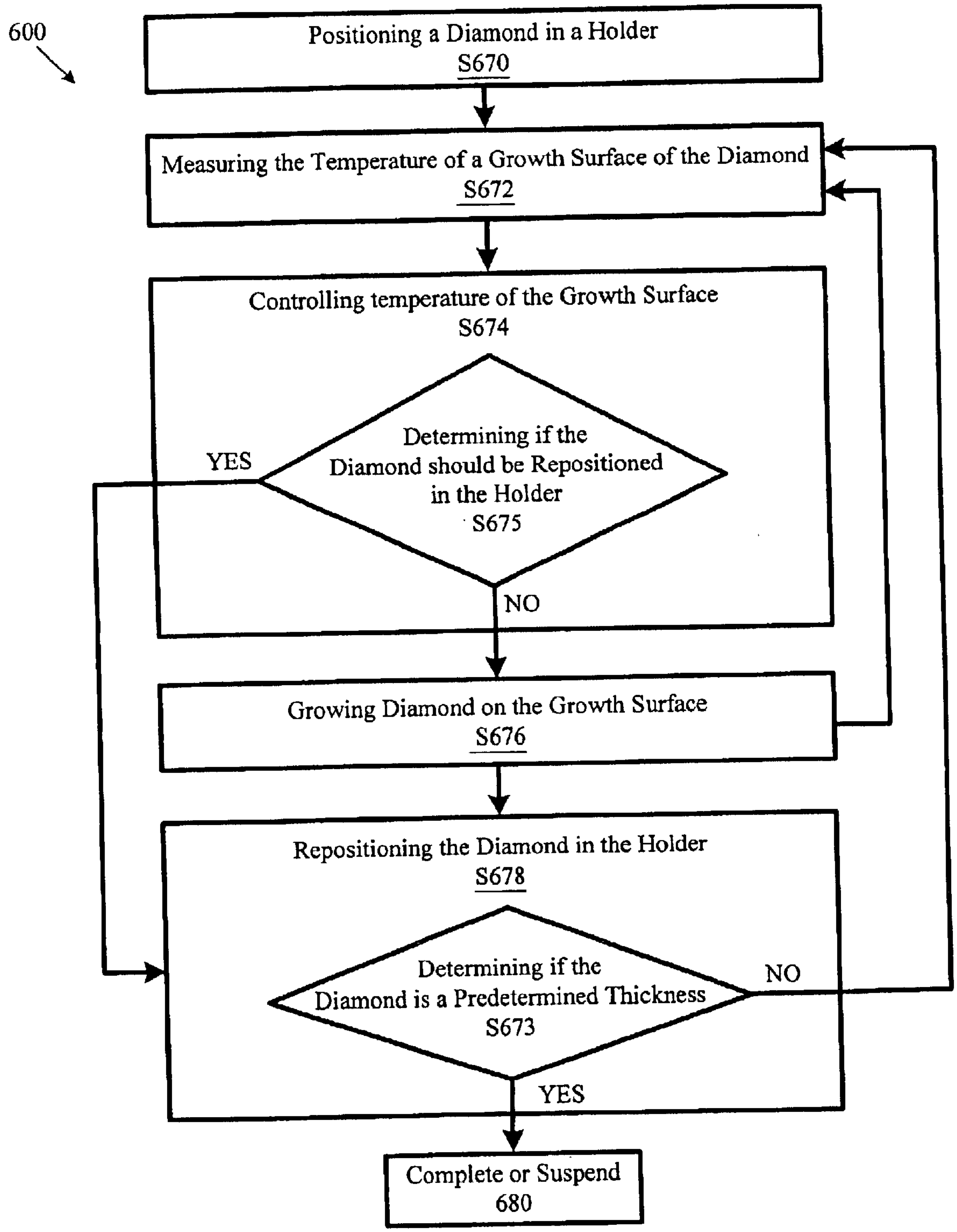
600
Positioning a Diamond in a Holder
S670
Measuring the Temperature of a Growth Surface of the Diamond
S672
Controlling temperature of the Growth Surface
S674
Determining if the Diamond should be Repositioned in the Holder
S675
YES
NO
Growing Diamond on the Growth Surface
S676
Repositioning the Diamond in the Holder
S678
Determining if the Diamond is a Predetermined Thickness
S673
NO
YES
Complete or Suspend
680

FIG. 6

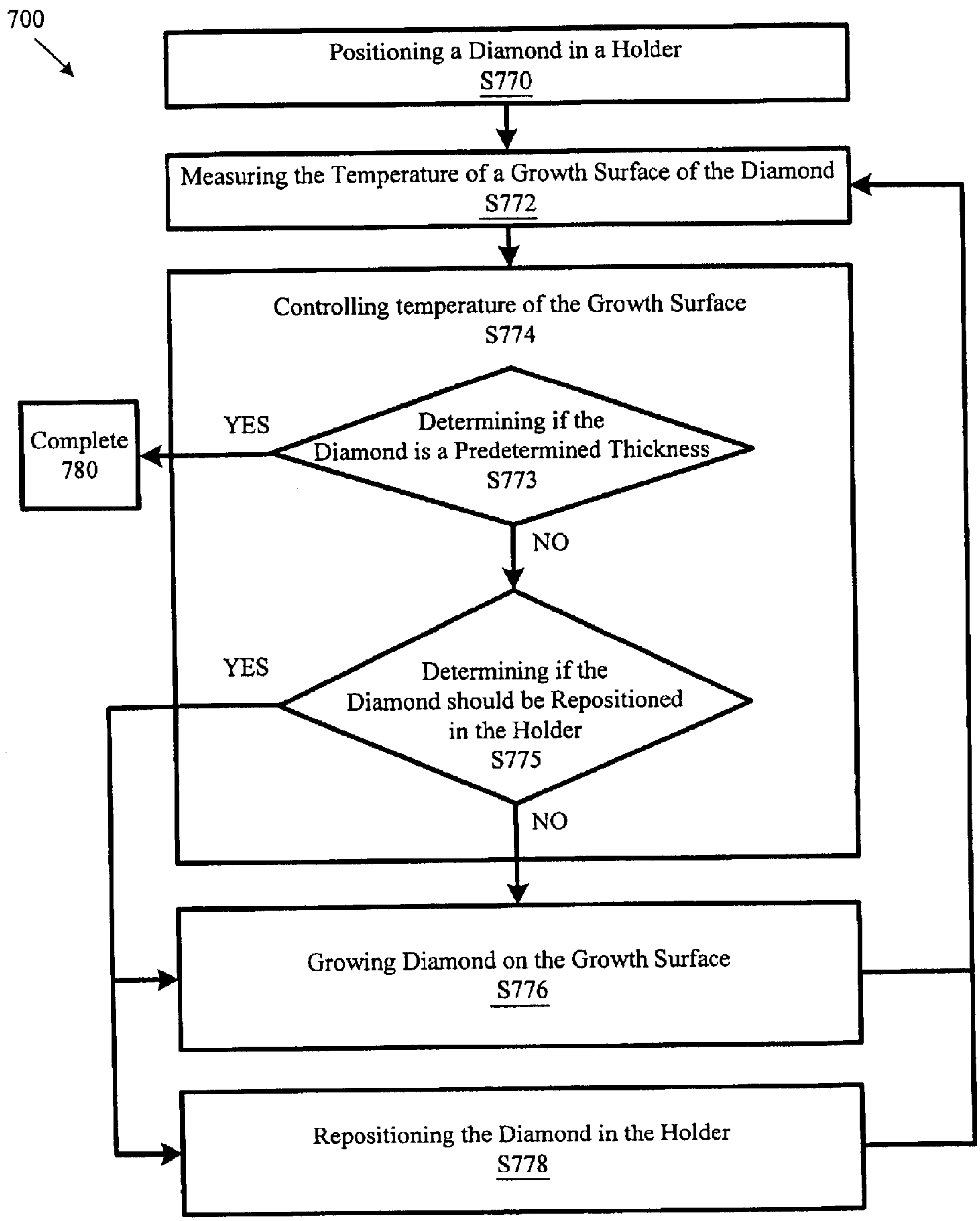
700
Positioning a Diamond in a Holder
S770
Measuring the Temperature of a Growth Surface of the Diamond
S772
Controlling temperature of the Growth Surface
S774
YES
Complete
780
Determining if the Diamond is a Predetermined Thickness
S773
NO
YES
Determining if the Diamond should be Repositioned in the Holder
S775
NO
Growing Diamond on the Growth Surface
S776
Repositioning the Diamond in the Holder
S778

FIG. 7

APPARATUS AND METHOD FOR DIAMOND PRODUCTION

The present invention claims the benefit of Provisional Application No. 60/331,073 filed on Nov. 7, 2001, which is hereby incorporated by reference in its entirety.

STATEMENT OF GOVERNMENT INTEREST

This invention was made with Government support under Grant Nos. EAR-8929239 and DMR-9972750 awarded by the National Science Foundation. The Government has certain rights in this invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus and a method for producing diamond, and more particularly, for growing diamond using Microwave Plasma Chemical Vapor Deposition (MPCVD) within a deposition chamber.

2. Description of Related Art

Large-scale production of synthetic diamond has long been an objective of both research and industry. Diamond, in addition to its gem properties, is the hardest known material, has the highest known thermal conductivity, and is transparent to a wide variety of electromagnetic radiation. Therefore, it is valuable because of its wide range of applications in a number of industries, in addition to its value as a gemstone.

For at least the last twenty years, a process of producing small quantities of diamond by chemical vapor deposition (CVD) has been available. As reported by B. V. Spitsyn et al. in "Vapor Growth of Diamond on Diamond and Other Surfaces," Journal of Crystal Growth, vol. 52, pp. 219–226, the process involves CVD of diamond on a substrate by using a combination of methane, or another simple hydrocarbon gas, and hydrogen gas at reduced pressures and temperatures of 800–1200° C. The inclusion of hydrogen gas prevents the formation of graphite as the diamond nucleates and grows. Growth rates of up to 1 μm/hour have been reported with this technique.

Subsequent work, for example, that of Kamo et al. as reported in "Diamond Synthesis from Gas Phase in Microwave Plasma," Journal of Crystal Growth, vol. 62, pp. 642–644, demonstrated the use of Microwave Plasma Chemical Vapor Deposition (MPCVD) to produce diamond at pressures of 1–8 Kpa in temperatures of 800–1000° C. with microwave power of 300–700 W at a frequency of 2.45 GHz. A concentration of 1–3% methane gas was used in the process of Kamo et al. Maximum growth rates of 3 μm/hour have been reported using this MPCVD process.

In the above-described processes, and in a number of more recently reported processes, the growth rates are limited to only a few micrometers per hour. Known higher-growth rate processes only produce or grow polycrystalline forms of diamond. Typically, attempts to produce single-crystal diamond at growth rates higher than about one micrometer per hour result in heavily twinned single crystal diamonds, polycrystalline diamond, or no diamond at all. Further, known processes for growing diamond usually require low pressures of less than 100 torr.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a an apparatus and a method for producing diamond that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention relates to an apparatus and method for producing diamond in a microwave plasma chemical vapor deposition system at a high growth rate and at moderate pressures.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, an embodiment of the apparatus for producing diamond in a deposition chamber includes a heat-sinking holder for holding a diamond and for making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, a noncontact temperature measurement device positioned to measure temperature of the diamond across the growth surface of the diamond and a main process controller for receiving a temperature measurement from the noncontact temperature measurement device and controlling temperature of the growth surface such that all temperature gradients across the growth surface are less than 20° C.

In another embodiment, a specimen holder assembly for producing diamond includes a diamond, a heat-sinking holder making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, wherein the diamond is slidably mounted within the heat-sinking holder, a stage for receiving thermal energy from the heat-sinking holder, and a first actuator member that can translate along an axis substantially perpendicular to the growth surface for repositioning the diamond within the heat-sinking holder.

In another embodiment, a specimen holder assembly for producing diamond includes a diamond, a heat-sinking holder making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, a thermal mass for receiving thermal energy from the heat-sinking holder, wherein the diamond is retained in the heat-sinking holder by pressure applied through the thermal mass, and a stage for receiving thermal energy from the heat-sinking holder via the thermal mass.

In accordance with another embodiment of the present invention, a method for producing diamond includes positioning diamond in a holder such that a thermal contact is made with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, measuring temperature of the growth surface of the diamond to generate temperature measurements, controlling temperature of the growth surface based upon the temperature measurements, and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface, wherein a growth rate of the diamond is greater than 1 micrometer per hour.

In accordance with another embodiment of the present invention, a method for producing diamond includes positioning diamond in a holder, measuring temperature of a growth surface of the diamond to generate temperature measurements, controlling temperature of the growth surface with a main process controller using the temperature measurements such that all temperature gradients across the growth surface are less than 20° C., growing diamond on the growth surface and repositioning the diamond in the holder.

In accordance with another embodiment of the present invention, a method for producing diamond includes con-

trolling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C. and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr.

In accordance with another embodiment of the present invention, a method for producing diamond includes controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C.; and growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a temperature of 900–1400° C.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

FIG. **1** is a diagram of a diamond production apparatus according to an embodiment of the present invention in which a cross-section of deposition apparatus with a specimen holder assembly for holding the diamond stationary during a diamond growth process is depicted.

FIG. **2***a* is a perspective view of the deposition apparatus shown in FIG. **1**.

FIG. **2***b* is a perspective view of the diamond and sheath shown in FIG. **1**.

FIG. **3** is a diagram of a diamond production apparatus according to an embodiment of the present invention in which a cross-section of a deposition apparatus with a specimen holder assembly for moving the diamond during the diamond growth process is depicted.

FIGS. **4***a*–**4***c* depict cross-sectional views of holders or thermal masses that can be used in accordance with the present invention.

FIG. **5** is a diagram of a diamond production apparatus according to another embodiment of the present invention in which a cross-section of a deposition apparatus with a specimen holder assembly for moving the diamond during the diamond growth process is depicted.

FIG. **6** is a flow diagram illustrating a process **600** in accordance with embodiments of the present invention that can be used with the specimen holder assembly shown in FIG. **1**.

FIG. **7** is a flow diagram illustrating a process **700** in accordance with embodiments of the present invention that can be used with the specimen holder assembly shown in FIG. **3** or with the specimen holder assembly shown in FIG. **5**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. FIG. **1** is a diagram of a diamond production system **100**, according to an embodiment of the present invention, in which a deposition apparatus **102** is depicted in cross-section. The diamond production system **100** includes a Microwave Plasma Chemical Vapor Deposition (MPCVD) system **104** that contains a deposition apparatus **102** as well as reactant and plasma controls **106**. For example, the MPCVD system **104** can be a WAVEMAT MPDR 330 313 EHP made by Wavemat, Inc. Such a MPCVD system is capable of producing a 6-kilowatt power output at a frequency of 2.45 GHz, and has a chamber volume of approximately 5,000 cubic centimeters. However, the MPCVD system specifications can vary with the scale of a deposition process in terms of size of the deposition area and/or rate of deposition.

The MPCVD system **104** includes a chamber within the deposition apparatus **102** that is at least in part defined by a bell jar **108**, which is used in sealing the chamber. Prior to MPCVD operations, the air within the chamber is withdrawn. For example, a first mechanical type of vacuum pump is used to draw down the chamber and then a second high vacuum type of vacuum pump, such as a turbopump or cryopump, further draws out the air inside the chamber. Plasma is generated within the chamber by a set of plasma electrodes spaced apart within the chamber. Neither the pumps nor the plasma electrodes are illustrated in FIG. **1**.

The deposition apparatus **102** also includes a specimen holder assembly **120** installed within the chamber of the MPCVD system **104**. Typically, a specimen holder assembly is positioned in the center of the deposition chamber floor **122** of the deposition apparatus **102**, as shown in FIG. **1**. The specimen holder assembly **120** shown in FIG. **1** is illustrated in cross-section. The specimen holder assembly **120** can include a stage **124** installed in the floor of the deposition apparatus **102**.

As shown in FIG. **1**, the stage **120** can be attached to the deposition chamber floor **122** using bolts **126***a* and **126***c*. The stage **124** can be molybdenum or any other type of material having a high thermal conductivity. In addition, the stage **124** can be cooled during the process of growing diamond by a coolant passing through a coolant pipe **128** within the stage **124**. The coolant can be water, a refrigerant or other types of fluid with sufficient heat carrying capacity to cool the stage. Although the coolant pipe is shown as having a U-shaped path through the stage **124** in FIG. **1**, the coolant pipe **128** can have a helically shaped path or other types of paths within the stage **124** to more efficiently cool the stage **124**.

Positioned on the stage **124** of the specimen holder assembly **120**, as shown in FIG. **1**, is a set ring **130** having set screws, such as screws **131***a* and **131***c*, for tightening collets **132***a* and **132***b* around a sheath **134** that holds diamond **136**. The sheath **134** is a holder, which makes a thermal contact with a side surface of the diamond **136** adjacent to an edge of a top surface of the diamond **136**. Because collets **132***a* and **132***b* are tightened onto the sheath **134** by screws **131**, the sheath **134** holds the diamond **136** in a stationary position and acts as a heat-sink to prevent the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond **136**.

The diamond **136** can include a diamond seed portion **138** and a grown diamond portion **140**. The diamond seed portion **138** can be a manufactured diamond or a natural diamond. As shown in FIG. **1**, the top surface or growth surface of the diamond **136** is positioned within a region of the plasma **141** having a resonant power at a height H above the deposition chamber floor **122**. The resonant power can be the maximum resonant power within the plasma **141** or a degree thereof. The top surface or growth surface of the diamond **136** is initially the diamond seed portion **138** and is then the grown diamond portion **140** as the diamond grows.

As shown in FIG. **1**, the top edge of the sheath **134** is at a distance D just below the top surface or top edges of the diamond **136**. The distance D should be sufficiently large enough to expose the edges of the growth surface of the diamond **136** to the plasma **141**. However, the distance D can not be so large as to prevent the heat-sinking effect of the sheath **134** that prevents the formation of twins or polycrystalline diamond along the edges of the growth surface of the diamond **136**. Thus, D should be within a specified distance range, such as 0–1.5 mm. The distance D and the height H, as shown in FIG. **1**, are manually set using the screws **131** of the set ring **130** by positioning the diamond **136** in the sheath, positioning the sheath in the collets **132***a* and **132***b*, and then tightening the screws **131**.

FIG. **2** is a perspective view of the deposition apparatus shown in FIG. **1**. In the center of the deposition chamber floor **122** of FIG. **2** is a circular stage **124** with a central recess **125**. As shown in FIG. **2**, the stage **124** is held in position by bolts **126***a*–**126***d*. The stage **124** can be formed of molybdenum or other materials having a high thermal conductivity. A set ring **130** with four screws **131***a*–**131***b* is positioned within the recess **125** of the stage **124** along with collets **132***a*–**132***b*. In the alternative, the set ring **130** can be bolted to the stage **124** to increase thermal conductance between the stage and the set ring.

As shown in FIG. **2***a*, a rectangular sheath **134**, which can either be a short length of rectangular tubing or a sheet folded into a rectangle, is positioned in the collets **132***a* and **132***b* with a diamond **136** therein. The sheath **124** can be molybdenum or any other type of material having a high thermal conductivity. The screws **131***a*–**131***d* are tightened on the collets **132***a*–**132***b* such that the sheath **134** is tightened onto the diamond **136** such that the sheath **134** acts as a heat sink on the four side surfaces of the diamond **136**. As shown in FIG. **1**, the sheath **134** also makes thermal contact to the stage **124**. The collets **132***a*–**132***b* make thermal contact with the stage **124** and serve as thermal masses for transferring heat from the sheath **134** into the stage **124**. The tightening of the sheath **134** onto the diamond **136** increases the quality of the thermal contact between the diamond and the sheath. As shown in FIG. **1**, the sheath **134** can also make thermal contact to the stage **124**. Although a rectangular shape is shown in FIG. **2***a* for both the sheath and the diamond, the sheath and the diamond can have any geometric shape such as elliptical, circular or polygonal. The shape of the sheath or holder should be substantially the same as the diamond.

In the exemplary embodiment of the invention shown in FIGS. **1** and **2***a*, the stage **124** can have a diameter of approximately 10.1 cm. and the sheath **134** can be approximately 2.5 cm wide. Regardless of the dimensions selected for the stage and the sheath **134**, the thermal mass of the stage **122**, molybdenum sheath **124**, and collets **132** can be adjusted to provide an optimal heat sink for the diamond **136**. Additionally, the path and extent of the coolant pipes **128** can be modified for greater cooling effect, especially if a particularly large diamond is to be produced. Further, a refrigerant or other low temperature fluids can be used as a coolant.

Molybdenum is only one potential material used in the stage **124**, set ring **130**, collets **132**, sheath **134** and other components. Molybdenum is suitable for these components because it has a high melting point, which is 2617° C., and a high thermal conductivity. In addition, a large graphite build-up does not tend to form on molybdenum. Other materials, such as molybdenum-tungsten alloys or engineered ceramics, having high melting points above the process temperature and a thermal conductivity comparable to that of molybdenum, can alternatively be used instead of molybdenum.

Returning to FIG. **1**, another component of the diamond production system **100** is an noncontact measurement device, such as an infrared pyrometer **142**, which is used to monitor the temperature of the diamond seed **138** and later the grown diamond **140** during the growth process without contacting the diamond **136**. The infrared pyrometer **142** can be, for example, a MMRON M77/78 two color infrared pyrometer from Mikron Instruments, Inc. of Oakland, N.J. The infrared pyrometer **142** is focused on the diamond seed **138** or later on the grown diamond **140** with a target area measure of 2 mm. By using the infrared pyrometer **142**, the temperature of the growth surface of the diamond **136** is measured to within 1° C.

The diamond production system **100** of FIG. **1** also includes an MPCVD process controller **144**. The MPCVD process controller **144** is typically provided as a component of the MPCVD system **104**. As is well-known in the art, the MPCVD process controller **144** exercises feedback control over a number of MPCVD parameters, including, but not limited to, the process temperature, gas mass flow, plasma parameters, and reactant flow rates by using the reactant and plasma controls **106**. The MPCVD process controller **144** operates in cooperation with a main process controller **146**. The main process controller **146** takes input from the MPCVD controller **144**, the infrared pyrometer **142**, and from other measuring devices of other components in the diamond production system **100** and carries out executive-level control over the process. For example, the main process controller **146** can measure and control coolant temperatures and/or flow rates of the coolant in the stage using a coolant controller **148**.

The main process controller **146** can be a general purpose computer, a special purpose computing system, such as an ASIC, or any other known type of computing system for controlling MPCVD processes. Depending on the type of main process controller **146**, the MPCVD process controller **144** can be integrated into the main process controller so as to consolidate the functions of the two components. For example, the main process controller **146** can be a general purpose computer equipped with the LabVIEW programming language from National Instruments, Inc. of Austin, Tex. and the LabVIEW program such that the general purpose computer is equipped to control, record, and report all of the process parameters.

The main process controller **146** in FIG. **1** controls the temperatures of the growth surface such that all the temperature gradients across the growth surface of the diamond are less than or equal to 20° C. Precise control over growth surface temperatures and growth surface temperature gradients prevents the formation of polycrystalline diamond or twins such that a large single crystal diamond can be grown. The ability to control all of the temperature gradients across the growth surface of the diamond **136** is influenced by several factors, including the heat sinking capability of the stage **124**, the positioning of the top surface of the diamond in the plasma **141**, the uniformity of the plasma **141** that the growth surface of the diamond is subjected to, the quality of thermal transfer from edges of the diamond via the holder or sheath **134** to the stage **124**, the controllability of the microwave power, coolant flow rate, coolant temperature, gas flow rates, reactant flow rate and the detection capabilities of the infrared pyrometer **142**. Based upon temperature measurements from the pyrometer **142**, the main process controller **146** controls the temperature of the growth surface

such that all temperature gradients across the growth surface are less than 20° C. by adjusting at least one of microwave power to the plasma **141**, the coolant flow rate, coolant temperature, gas flow rates and reactant flow rate.

FIG. **2***b* is a perspective view of the diamond **136** shown in FIG. **1** depicting exemplary points **P1**, **P2**, **P3** and **P4** along the growth surface **137** of the diamond **136**. FIG. **2***b* also depicts the distance D between the growth surface **137** or top edges **139** of the diamond **136** and an edge **135** of the sheath **134**. Typically, large temperature variations, in terms of temperature differences across the growth surface, occur between the edges and the middle of the growth surface of the diamond. For example, larger temperature gradients occur between the points **P1** and **P2** than occur between the points **P1** and **P3**. In another example, larger temperature gradients occur between the points **P4** and **P2** than occur between the points **P4** and **P3**. Thus, controlling temperature of the growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C. should at least take into account a temperature measurement between the middle and an edge **139** of the growth surface **137**. For example, the main controller **146** may control the temperature of the growth surface such that the temperature gradient between points **P1** and **P2** is less than 20° C.

The spot size of the infrared pyrometer can affect the ability to monitor temperature gradients across the top surface of the diamond and thus the growth rate of the diamond. For example, if the size of the diamond is large in comparison to the spot size of the infrared pyrometer, the temperature at each of the edges of the growth surface of the diamond can be outside of the field of view of the infrared pyrometer. Thus, multiple infrared pyrometers should be used for a diamond with a large growing area. Each of the multiple pyrometers should be focused on different edges about the surface of the diamond and preferably near the corners, if any. Thus, the main process controller **146**, as shown in FIG. **1**, should be programmed to integrate overlapping fields of view from the multiple pyrometers to produce a contiguous "map" of the temperatures across the diamond's surface or interpolate between non-overlapping fields of view to a produce an interpreted "map" of the temperatures across the diamond's growth surface. In the alternative, the temperature gradient between a single edge or corner point with respect to the middle of the growth surface can be monitored as indicative of the maximum temperature gradient that exists across the growth surface of the diamond.

In addition to the infrared pyrometer **142** for temperature control, other process control instrumentation may be included in the diamond production system **100**. Additional process control instrumentation can include equipment for determining the type and quality of the diamond **136** while the growth process is underway. Examples of such equipment include visible, infrared, and Raman spectrometers, which are optical in nature and can be focused on the same point as the infrared pyrometer **142** to obtain data on the structure and quality of the diamond while growth is underway. If additional equipment is provided, it can be connected to the main process controller **146** such that the main process controller **146** controls the instrumentation and presents the results of the analytical methods along with other status information. Additional process control instrumentation may be particularly useful in experimental settings, in "scaling up" a process to produce larger diamonds, and in quality control efforts for an existing diamond production system **100** and corresponding process.

As the diamond **136** grows, both the distance D and the height H increase. As the distance D increases, the heat-sinking capacity of the sheath **134** for the top edges **139** of the growth surface of the diamond **136** reduces. In addition, characteristics of the plasma, such as temperature and/or consistency, change as the growth surface of the diamond **136** extends into the plasma **141**. In the diamond production system **100**, the growth process is periodically halted so that the position of the diamond **136** can be adjusted downward with respect to the sheath **134** to reduce the distance D, and both the diamond **136** and the sheath **134** can be adjusted downward with respect to the deposition chamber floor **122** to reduce the height H. This repositioning allows the diamond growth of on the growth surface of the diamond **136** to occur within a desired region of resonant power within the plasma **141**, allows the infrared pyrometer **142** and any additional instruments to remain focused on the growth surface of the diamond **136**, and has the effect of maintaining an efficient thermal contact for sinking heat from the edges of the growth surface of the diamond **136**. However, repeatedly halting the growth process can be inconvenient for large-scale production, and increases the chance of introducing contamination into the process if not carefully performed.

FIG. **3** is a diagram of a diamond production apparatus **300** according to an embodiment of the present invention in which a cross-section of deposition apparatus **304** with a specimen holder assembly **320** for moving the diamond **136** during the diamond growth process is depicted. Some of the components of diamond production apparatus **300** are substantially the same as those of diamond production system **100**, and thus, the discussion above with regard to FIG. **1** will suffice to describe those components likewise numbered in FIG. **3**. For example, the pyrometer **142**, deposition chamber floor **122**, coolant pipe **128** and bell jar **108** in FIG. **3** are substantially the same as those described in FIG. **1**.

As shown in FIG. **3**, the diamond **136** is mounted on a diamond actuator member **360** within the sheath **134** of the specimen holder assembly **320**. The diamond **136** is slidably mounted within the sheath **134** on a diamond actuator member **360** that translates along an axis substantially perpendicular to the growth surface. The diamond actuator member **360** protrudes through a stage **324** and is controlled from underneath the stage **324** with a diamond control, which is shown as a part of the coolant and diamond/holder controls **329** in FIG. **3**. The diamond actuator member **360** is for setting the height H between the growth surface of the diamond **136** and the deposition chamber floor **122**. Although the diamond actuator member **360** in FIG. **3** is shown as a threaded rod, the diamond actuator member can be of any geometric shape that enables positioning of the diamond **136** at height or position above the deposition chamber floor. Those skilled in the art will realize that components placed within the bell jar, such as the diamond actuator member **360**, should be vacuum compatible so as to avoid problems in maintaining the desired atmosphere.

The actuator (not shown) for the diamond actuator member **360** is a motor (not shown). However, the actuator can be any one of a number of known types of actuator, depending on the size of diamond that is to be grown, the growth rate, and the level of movement precision required. For example, if the diamond **136** is small in size, a piezoelectric actuator may be used. If the diamond **136** is relatively large or can be grown relatively large, a motorized computer-controllable actuator is preferred. Regardless of the particular actuator employed, the main process controller **346** controls the movement of the diamond actuator member **360** so that the diamond **136** can be automatically moved downward as diamond growth progresses.

In addition, a holder actuator member **362** protrudes through the stage **324** and is controlled from underneath the stage **324** with holder control, which is shown as a part of the coolant and diamond/holder controls **329** in FIG. **3**. The holder actuator member **362** translates along an axis substantially perpendicular to the growth surface and is for maintaining the distance D between an edge of the growth surface of the diamond **136** and a top edge of the holder or sheath **134**. A diamond production system can have a diamond actuator member, a holder actuator member, or a combination of both.

The holder actuator member **362** in FIG. **3** is threaded into the stage **324** and the diamond actuator member **360** is threaded into the holder actuator member **362**. By this arrangement, the diamond and holder controls of the coolant and diamond/holder controls **329** shown in FIG. **3** can move the diamond **136**, the sheath **134**, or both the sheath **134** and the diamond **136**. Although the holder actuator member **362** in FIG. **3** is shown as a threaded cylinder with threading on the inside for the diamond actuator member **360** and threads on the outside for threading into the stage **324**, the holder actuator member can be of any geometric shape that enables maintaining a specified distance range between an edge of the growth surface of the diamond **136** and the top edge of the holder or sheath **134**. Those skilled in the art will realize that components placed within the bell jar, such as the holder actuator member **362** or a combination of both the holder actuator member and the diamond actuator member, should be vacuum compatible so as to avoid problems in maintaining the desired atmosphere.

As shown in FIG. **3**, a thermal mass **364** is positioned within a recess of the stage **324**. The holder or sheath **134** is slidably positioned within thermal mass **364** such that thermal energy is transferred from the sheath **134** to the stage **324**. The top surface of the thermal mass **364** can be contoured such that heat can be transferred from the sheath **134** while minimizing the electrical effect of the thermal mass **364** on the plasma **341**. Thermal masses **466***a*, **466***b* and **466***c* in FIGS. **4***a*–**4***c*, respectively, are examples of other contoured thermal masses with different cross-sectional shapes, which in the alternative, can be used in lieu of the thermal mass **364** shown in FIG. **3**. A thermal mass can be made of molybdenum. Other materials, such as molybdenum-tungsten alloys or engineered ceramics, having high melting points above the process temperature and a thermal conductivity comparable to that of molybdenum can be used as a thermal mass for transferring heat from a side of the diamond to a stage.

By minimizing the electrical effect of thermal mass **364** on the plasma **341**, the region within the plasma **341** in which the diamond is grown will be more uniform. In addition, higher pressure can be used in growing diamond, which will increase the growth rate of single-crystal diamond. For example, pressures can vary from 130 to 400 torr and single-crystal growth rates can be from 50 to 150 microns per hour. Using a higher pressure, such as 400 torr, is possible because the uniformity, shape and/or position of the plasma **341** are not as readily affected by thermal mass **364**, which is contoured to remove heat from the edges of the growth surface of the diamond and minimizes the electrical effect of the thermal mass **364** on the plasma **341**. In addition, less microwave power, such as 1–2 kW, is needed to maintain the plasma **341**. Otherwise, a lower pressure and/or increased microwave power would have to be used to maintain the uniformity, shape and/or position of the plasma **341**.

As the diamond **136** grows, both the distance D and the height H increase. As the distance D increases, the heat-sinking capacity of the sheath **134** for the top edges of the growth surface of the diamond **136** decreases. In addition, characteristics of the plasma, such as temperature, change as the growth surface of the diamond **136** extends into the plasma **341**. In the diamond production system **300**, the growth process is halted when the diamond **136** reaches a predetermined thickness since the distance D and the height H can be controlled by the main process controller **346**, via the coolant and diamond/holder controls **329**, using the holder actuator member **362** and diamond actuator member **360** during the diamond growing process. This repositioning, either manually or automatically under control of the controller **144**, allows the diamond growth on the growth surface of the diamond **136** to occur within a desired region of resonant power within the plasma **341**. Further, repositioning allows the infrared pyrometer **142** and any additional instruments to remain focused on the growth surface of the diamond **136**, and can maintain an efficient sinking of heat from the edges of the growth surface of the diamond **136**.

FIG. **5** is a diagram of a diamond production apparatus **500** according to an embodiment of the present invention in which a cross-section of deposition apparatus **504** with a specimen holder assembly **520** for moving the diamond **136** during the diamond growth process is depicted. Some of the components of diamond production apparatus **500** are substantially the same as those of diamond production system **100** and **300**, and thus, the discussion above with regard to FIG. **1** and FIG. **3** will suffice to describe those components likewise numbered in FIG. **5**. For example, the pyrometer **142**, deposition chamber floor **122**, coolant pipe **128** and bell jar **108** in FIG. **5** are substantially the same as those described in FIG. **1**. In another example, the coolant and diamond/holder controller **329** and diamond actuator member **360** in FIG. **5** are substantially the same as those in FIG. **3**.

As shown in FIG. **5**, the diamond **136** is mounted on the diamond actuator member **360** and within a contoured thermal mass **566**, which acts as a holder. By placing the diamond **136** directly within the contoured thermal mass **566**, thermal efficiencies for heat-sinking the diamond **136** are increased. However, the plasma **541** may be more easily affected since the whole contoured thermal mass is moved by the holder actuator **562** in the stage **524** with a diamond holder control, which is shown as a part of the coolant and diamond/holder controls **329** in FIG. **3**. Thus, the main process controller **546** should take into account such a factors for appropriately controlling the plasma and/or other parameters of the growth process. In the alternative, the convex thermal mass **364** shown in FIG. **3**, the slant-sided thermal mass **466***b* in FIG. **4***b*, a slant-sided/cylindrical apex thermal mass **466***c* in FIG. **4***c* or other geometric configurations can be used in lieu of the concave thermal mass **566**, in FIG. **5**.

FIG. **6** is a flow diagram illustrating a process **600** in accordance with embodiments of the present invention that can be used with specimen holder assembly shown in FIG. **1**. The process **600** begins with step **S670** in which an appropriate seed diamond or a diamond in the process of being grown is positioned in a holder. In the specimen holder assembly **120** of FIG. **1** for example, the diamond seed portion **138** is placed in a sheath **134** and the screws **131***a*–**131***d* are tightened by an operator. Other mechanisms can be used to maintain both the sheath and diamond in position, such as spring loaded collets, hydraulics or other mechanisms can be used in exerting a force against the holder or sheath.

As referred to in step **S672**, the temperature of the growth surface of the diamond, either the diamond seed or grown diamond, is measured. For example, the pyrometer **142** in FIG. **1** takes a measurement of the growth surface, which is the top surface of the growing diamond portion **140**, and provides the measurement to the main process controller **146**. The measurement is taken such that a thermal gradient across the growth surface of the diamond **136** can be determined by the main process controller or at least the temperature of an edge of the growth surface of the diamond are inputted into the main process controller.

The main process controller, such as main process controller **146** shown in FIG. **1**, is used in controlling the temperature of the growth surface, as referred to in **S674** in FIG. **6**. The main process controller controls the temperature by maintaining thermal gradients of less than 20° C. across the growth surface. While controlling the temperature of the growth surface, a determination is made to whether the diamond should be repositioned in the holder, as shown in step **S675** of FIG. **6**. If the main controller can not control the temperature of the growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C. by controlling the plasma, gas flows and coolant flows, then the growth process is suspended so that the diamond can be repositioned in the holder, as shown in step **S678** of FIG. **6**, for better heat-sinking of the diamond and/or better positioning of the diamond within the plasma. If the main controller can maintain all of the thermal gradients across the growth surface of the diamond to be less than 20° C., then the growing of the diamond on the growth surface occurs as shown in step **S676** of FIG. **6**.

Measuring the temperature of a growth surface of the diamond, controlling temperature of the growth surface and growing diamond on the growth surface occurs until it is determined that the diamond should be repositioned, as shown in FIG. **6**. Although measuring, controlling, growing and the acts of determining are shown and described as steps, they are not necessarily sequential and can be concurrent with one another. For example, the step of growing diamond on the growth surface can occur while measuring the temperature of a growth surface of the diamond and controlling temperature of the growth surface are occurring.

The repositioning of the diamond, as referred to in step **S678**, can be done manually or with a robotic mechanism. In addition, a determination can be made of whether the diamond has reached a predetermined or desired thickness, as shown in step **S673** of FIG. **6**. The determination can be based on an actual measurement via mechanical or optical devices. In another example, the determination can be based on the length of processing time in view of known growth rates for the process. If the diamond has reached the predetermined thickness, then the growing process is complete, as referred to by step **680** in FIG. **6**. If the diamond has not reached the predetermined thickness, then the growth process is started again and continues with measuring the temperature of a growth surface of the diamond, controlling temperature of the growth surface and growing diamond on the growth surface until it is determined that the diamond needs to be repositioned, as shown in FIG. **6**.

FIG. **7** is a flow diagram illustrating a process **700** in accordance with embodiments of the present invention that can be used with specimen holder assembly shown in FIG. **3** and FIG. **5**. The process **700** begins with step **S770** in which an appropriate seed diamond, which can be a grown diamond, manufactured diamond, natural diamond or combination thereof, is positioned in a holder. In the specimen holder assembly **320** of FIG. **3** for example, the diamond seed portion **138** is placed with in sheath **134** on the diamond actuator member **360**, as shown in FIG. **3**. In another example of a specimen holder assembly, the diamond seed portion **138** is placed within a contoured thermal mass **566** on the diamond actuator **360**, as shown in FIG. **5**.

As referred to in step **S772**, the temperature of the growth surface of the diamond, either the diamond seed or a newly grown diamond portion on the diamond seed, is measured. For example, the pyrometer **142** in FIG. **3** takes a measurement of the growth surface, which is the top surface of the growing diamond portion **140**, and provides the measurement to the main process controller **346**. In another example, the pyrometer **142** in FIG. **5** takes a measurement of the growth surface, which is the top surface of the seed diamond portion **138**, and provides the measurement to the main process controller **546**. The measurement is taken such that thermal gradient across the growth surface of the diamond can be determined by the main process controller or at least the temperatures of an edge and the middle of the growth surface are inputted into the main process controller.

A main process controller, such as main process controller **346** or **546**, is used in controlling the temperature of the growth surface, as referred to in **S774** in FIG. **7**. The main process controller controls the temperature of the growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C. While controlling the temperature of the growth surface, a determination is made to whether the diamond needs to be repositioned in the holder, as shown in step **S775** of FIG. **7**. If the main controller can not maintain the temperature of the growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C. by controlling the plasma, gas flows and coolant flows, then the diamond is repositioned while the diamond is growing as shown in FIG. **7** with the "YES" path from step **S775** to both of steps **S776** and **S778**. By repositioning the diamond within the holder, the heat-sinking of the edges of the growth surface is improved. In addition, the growth surface can be positioned within an optimal region of the plasma having a consistency for maintaining all of the thermal gradients across the growth surface of the diamond to be less than 20° C. If the main controller can maintain all of the thermal gradients across the growth surface of the diamond to be less than 20° C., then the growing of the diamond on the growth surface occurs without repositioning as shown in the "NO" path from step **S775** to step **S776** of FIG. **7**.

Measuring the temperature of a growth surface of the diamond, controlling temperature of the growth surface, growing diamond on the growth surface and repositioning the diamond in the holder occurs until it is determined that the diamond has reached a predetermined thickness. As referred to in step **S773** of FIG. **7**, if a determination is made of whether the diamond has reached a predetermined or desired thickness. The determination can be based on an actual measurement via mechanical or optical devices. For example, a tracking program which records the depth or the amount in terms of distance that the diamond had to be repositioned during the growth process. In another example, the determination can be based on the length of processing time in view of known growth rates for the growth process. If the diamond has reached the predetermined thickness, then the growing process is complete, as referred to by step **780** in FIG. **7**. If the diamond has not reached the predetermined thickness, then the growth process continues with measuring the temperature of a growth surface of the diamond, controlling temperature of the growth surface, growing diamond on the growth surface and repositioning

the diamond in the holder until it is determined that the diamond needs to be repositioned, as shown in the "NO" path from **S773** to within **S774** of FIG. **7**.

When implementing processes **600** and **700**, diamond growth is usually continued as long as a "step growth" condition can be maintained. In general, the "step growth" condition refers to growth in which diamond is grown on the growth surface of the diamond **136** such that the diamond **136** is smooth in nature, without isolated "outcroppings" or twins. The "step growth" condition may be verified visually. Alternatively, a laser could be used to scan the growth surface of the diamond **136**. A change in laser reflectance would indicate the formation of "outcroppings" or twins. Such a laser reflectance could be programmed into the main process controller as a condition for stopping the growth process. For example, in addition to determining if the diamond is a predetermined thickness, a determination can also be made of whether a laser reflectance is being received.

In general, the methods in accordance with exemplary embodiments of the present invention are designed to create large, high-quality diamonds with increased [100] growth rates. The process temperature may be selected from a range of about 900–1400° C., depending on the particular type of single-crystal diamond that is desired or if oxygen is used. Polycrystalline diamond may be produced at higher temperatures, and diamond-like carbon may be produced at lower temperatures. During the growth process, a pressure of about 130–400 torr is used, with a methane concentration in the range of 6–12% methane. A hydrocarbon concentration greater than 15% may cause excessive deposition of graphite inside the MPCVD chamber. A 1–5% N_2/CH_4 added to the reactant mix creates more available growth sites, enhances the growth rate, and promotes {100} face growth. Other aspects of the invention can be understood in greater detail from the following examples.

EXAMPLE 1

A diamond growth process was conducted in the above-described MPCVD chamber in FIG. **1**. First, a commercial 3.5×3.5×1.6 mm^3 high pressure high temperature (HPHT) synthetic type Ib diamond seed was positioned in the deposition chamber. The diamond seed has polished, smooth surfaces that were ultrasonically cleaned with acetone. The deposition surface was within two degrees of the {100} surface of the diamond seed.

Then, the deposition chamber was evacuated to a base pressure of 10^{-3} torr. The infrared pyrometer **142** was focused though a quartz window at an incident angle of 65 degrees on the growth surface of the diamond and had a minimum 2 mm^2 diameter spot size. Diamond growth was performed at 160 torr pressure using gas concentrations of 3% N_2/CH_4, and 12% CH_4/H_2. The process temperature was 1220° C., and gas flow rates were 500 sccm H_2, 60 sccm CH_4, and 1.8 sccm N_2. Deposition was allowed to continue for 12 hours.

The resulting diamond was 4.2×4.2×2.3 mm^3 unpolished, and represented about 0.7 mm of growth on the seed crystal that was grown at a growth rate 58 microns per hour. The growth morphology indicated that the <100> side growth rate was faster than the <111> corner growth rate. The growth parameter, α, was estimated at 2.5–3.0.

The deposited diamond was characterized using x-ray diffraction (XRD), Raman spectroscopy, photoluminescence (PL) spectroscopy and electron paramagnetic resonance (EPR). The X-ray diffraction study of the resulting diamond confirmed that it was a single crystal, with a small degree of polycrystallinity localized at the top edges of the diamond. Visible/near infrared transmission spectra of the MPCVD grown diamond and seed diamonds confirm that nitrogen is incorporated effectively into the crystal structure. Raman spectroscopy demonstrates that the top face of the MPCVD grown diamond has different optical characteristics than the seed diamond but has the same internal stress.

A number of MPCVD diamonds were produced according to the guidelines of Example 1 while varying the described process temperature. These experiments demonstrate the process temperature ranges for producing various types of diamond in the growth process according embodiments of the present invention. Table 1 sets forth the results of these additional experiments.

TABLE 1

Process temperatures for various types of diamond

Temperature Range	Type of Diamond Produced
<1000° C.	Spherical, black diamond-like carbon (DLC)
1000–1100° C.	Smooth dark brown
1100–1200° C.	Brown
1200–1220° C.	Smooth, yellow tint growth
1220–1400° C.	Step-flow type with pyramid like octahedra tinted yellow
>1300° C.	Twinned or polycrystalline diamond

EXAMPLE 2

A high-quality, pure CVD single crystal diamond over 0.6 mm in thickness was created substantially in accordance with the procedure of Example I above by adding a small amount (1–3%) of oxygen and lowering the growth temperature to 900 degrees Celsius. The added oxygen allows a lower growth temperature, which removes the nitrogen-related impurities and reduces the silicon and hydrogen impurity levels. The growth rate using this process is approximately 10 m/hr, less than that of Example 1, but still greater than conventional processes.

The colors of diamond formed by the methods discussed above be changed by annealing. For example, a yellow of brown diamond can be annealed into a green diamond. Additional information with regard to the diamond produced in the examples described above is in a paper by the inventors entitled "Very High Growth Rate Chemical Vapor Deposition of Single-Crystal Diamond" Proceedings of the National Academy of the Sciences, Oct. 1, 2002, volume 99, no. 20., pages 12523–12525, which is hereby incorporated by reference in its entirety. Diamond produced by the above methods and apparatus will be sufficiently large, defect free and translucent so as to be useful as windows in high power laser applications or as anvils in high pressure apparatuses.

As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within the metes and bounds of the claims, or equivalence of such metes and bounds are therefore intended to be embraced by the appended claims.

What is claimed is:

1. A method for diamond production, comprising:

controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C.; and

growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a growth temperature in a deposition chamber having an atmosphere with a pressure of at least 130 torr.

2. The method of claim **1**, wherein the atmosphere includes hydrogen, 1–5% nitrogen per unit of hydrogen and 6–12% methane per unit of hydrogen.

3. The method of claim **2**, wherein the atmosphere further includes 1–3% oxygen per unit of hydrogen.

4. The method of claim **3**, wherein the growth temperature is 900–1400° C.

5. The method of claim **2**, wherein the atmosphere includes 3% nitrogen per unit of hydrogen and 12% methane per unit of hydrogen.

6. The method of claim **1**, wherein the pressure is 130–400 torr.

7. The method of claim **1**, wherein the growth temperature is 1000–1400° C.

8. The method of claim **1**, further comprising the step of:

positioning a diamond seed in a holder.

9. The method of claim **8**, further comprising the step of:

repositioning the diamond in the holder after the step of growing single-crystal diamond; and

repeating the step of growing single-crystal diamond.

10. The method of claim **8**, further comprising the step of:

repositioning the single-crystal diamond in the holder while growing the single-crystal diamond.

11. The method of claim **1**, wherein a growth rate of the single-crystal diamond is 1 to 150 micrometer per hour.

12. A method for diamond production, comprising:

controlling temperature of a growth surface of the diamond such that all temperature gradients across the growth surface are less than 20° C.; and

growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface at a temperature of 900–1400° C.

13. The method of claim **12**, wherein the atmosphere includes hydrogen, 1–5% nitrogen per unit of hydrogen and 6–12% methane per unit of hydrogen.

14. The method of claim **13**, wherein the atmosphere includes 3% nitrogen per unit of hydrogen and 12% methane per unit of hydrogen.

15. The method of claim **12**, wherein the atmosphere further includes 1–3% oxygen per unit of hydrogen.

16. The method of claim **12**, wherein a pressure of an atmosphere in which diamond growth occurs is 130–400 torr.

17. The method of claim **12**, further comprising the step of:

positioning a diamond seed in a holder.

18. The method of claim **17**, further comprising the steps of:

repositioning the diamond in the holder after the step of growing single-crystal diamond; and

repeating the step of growing single-crystal diamond.

19. The method of claim **17**, further comprising the step of:

repositioning the single-crystal diamond in the holder while growing the single-crystal diamond.

20. The method of claim **12**, wherein a growth rate of the single-crystal diamond is 1 to 150 micrometer per hour.

21. A method for diamond production, comprising:

positioning diamond in a holder such that a thermal contact is made with a side surface of the diamond adjacent to an edge of a growth surface of the diamond;

measuring temperature of the growth surface of the diamond to generate temperature measurements;

controlling temperature of the growth surface based upon the temperature measurements; and

growing single-crystal diamond by microwave plasma chemical vapor deposition on the growth surface, wherein a growth rate of the diamond is greater than 1 micrometer per hour.

22. The method of claim **21**, wherein the atmosphere includes hydrogen, 1–5% nitrogen per unit of hydrogen and 6–12% methane per unit of hydrogen.

23. The method of claim **22**, wherein the atmosphere further includes 1–3% oxygen per unit of hydrogen.

24. The method of claim **23**, wherein the growth temperature is 900–1400° C.

25. The method of claim **21**, wherein the atmosphere includes 3% nitrogen per unit of hydrogen and 12% methane per unit of hydrogen.

26. The method of claim **21**, wherein the pressure is 130–400 torr.

27. The method of claim **21**, wherein the growth temperature is 1000–1400° C.

28. The method of claim **21**, further comprising the steps of:

repositioning the diamond in the holder after the step of growing diamond; and

growing diamond by microwave plasma chemical vapor deposition on the growth surface again.

29. The method of claim **21**, further comprising the step of:

repositioning the diamond in the holder while growing diamond.

30. The method of claim **21**, further comprising the step of:

determining if the diamond should be repositioned in the holder.

31. The method of claim **21**, further comprising the steps of:

determining a thickness of the diamond; and

stopping the growth of diamond.

32. A method for diamond production, comprising:

positioning diamond in a holder;

measuring temperature of a growth surface of the diamond to generate temperature measurements;

controlling temperature of the growth surface with a main process controller using the temperature measurements such that all temperature gradients across the growth surface are less than 20° C.;

growing diamond on the growth surface; and

repositioning the diamond in the holder.

33. The method of claim **32**, further comprising the step of:

determining if the diamond should be repositioned in the holder.

34. The method of claim **32**, further comprising the step of:

determining a thickness of the diamond; and

stopping the growth of diamond.

35. The method of claim **32**, wherein the atmosphere includes hydrogen, 1–5% nitrogen per unit of hydrogen and 6–12% methane per unit of hydrogen.

36. The method of claim **32**, wherein the diamond is substantially single-crystal diamond.

37. The method of claim **32**, wherein the growth temperature is 900–1400° C.

38. The method of claim **32**, wherein the atmosphere includes 3% nitrogen per unit of hydrogen and 12% methane per unit of hydrogen.

39. The method of claim **32**, wherein the pressure is 130–400 torr.

40. The method of claim **32**, wherein the growth temperature is 1000–1400° C.

41. The method of claim **32**, wherein the step of growing diamond is repeated after repositioning the diamond in the holder.

42. The method of claim **32**, wherein repositioning the diamond within the holder occurs during the step of growing diamond.

43. The method of claim **32**, wherein a growth rate of the diamond is greater than 1 micrometer per hour and the diamond is single-crystal diamond.

44. An apparatus for diamond production in a deposition chamber, comprising:

a heat-sinking holder for holding a diamond and for making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond;

a noncontact temperature measurement device positioned to measure temperature of the diamond across the growth surface of the diamond; and

a main process controller for receiving a temperature measurement from the noncontact temperature measurement device and controlling temperature of the growth surface such that all temperature gradients across the growth surface are less than 20° C.

45. The apparatus of claim **44**, wherein the heat-sinking holder comprises a tubular section of molybdenum.

46. The apparatus of claim **44**, wherein the heat-sinking holder is positioned in, and transfers thermal energy to, a stage installed in the deposition chamber.

47. The apparatus of claim **46**, wherein the heat-sinking specimen holder makes thermal contact with a thermal mass, which transfers thermal energy to the stage.

48. The apparatus of claim **47**, wherein the diamond is retained in the heat-sinking specimen holder by screws tightening the thermal mass against the holder.

49. The apparatus of claim **44**, wherein the diamond is slidably mounted within the heat-sinking holder.

50. The apparatus of claim **44**, wherein the diamond is slidably mounted within the heat-sinking holder and mounted on a first actuator member that translates along an axis substantially perpendicular to the growth surface.

51. The apparatus of claim **50**, wherein the heat-sinking holder is position on a second actuator member that translates along an axis substantially perpendicular to the growth surface for maintaining a distance between an edge of the growth surface of the diamond and a top edge of the heat-sinking holder.

52. The apparatus of claim **44**, wherein the heat-sinking holder is position on a first actuator member and slidably within a thermal mass for receiving heat from the diamond.

53. The apparatus of claim **52**, wherein the diamond is slidably mounted within the heat-sinking holder and mounted on a second actuator member that translates along an axis substantially perpendicular to the growth surface.

54. The apparatus of claim **52**, wherein the thermal mass is a stage installed in the deposition chamber.

55. The apparatus of claim **52**, wherein the first actuator member translates along an axis substantially perpendicular to the growth surface for maintaining a distance between an edge of the growth surface of the diamond and a top edge of the heat-sinking holder.

56. The apparatus of claim **44**, wherein the noncontact temperature measurement device is an infrared pyrometer.

57. The apparatus of claim **44**, wherein the diamond is substantially single-crystal diamond.

58. A specimen holder assembly for diamond production, comprising:

a diamond;

a heat-sinking holder making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond, wherein the diamond is slidably mounted within the heat-sinking holder;

a stage for receiving thermal energy from the heat-sinking holder; and

a first actuator member that can translate along an axis substantially perpendicular to the growth surface for repositioning the diamond within the heat-sinking holder.

59. The assembly of claim **58**, wherein the heat-sinking holder is comprised of molybdenum.

60. The assembly of claim **58**, wherein the heat-sinking specimen holder makes thermal contact with a thermal mass, which transfers thermal energy to the stage.

61. The assembly of claim **58**, wherein the heat-sinking holder is position on a second actuator member that translates along an axis substantially perpendicular to the growth surface for maintaining a distance between an edge of the growth surface of the diamond and a top edge of the heat-sinking holder.

62. A specimen holder assembly for diamond production, comprising:

a diamond;

a heat-sinking holder making thermal contact with a side surface of the diamond adjacent to an edge of a growth surface of the diamond;

a thermal mass for receiving thermal energy from the heat-sinking holder, wherein the diamond is retained in the heat-sinking holder by pressure applied through the thermal mass; and

a stage for receiving thermal energy from the heat-sinking holder via the thermal mass.

63. The assembly of claim **62**, wherein the pressure is applied with a screw.

64. The assembly of claim **62**, wherein the thermal mass is collets.

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UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME LIMITATIONS

Case Number: 21-2249, 21-2315

Short Case Caption: Carnegie Institution of Washington v. Fenix Diamonds LLC

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Signature: /s/Nathan K. Kelley

Name: Nathan K. Kelley

UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

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Case Number: 21-2249, 21-2315

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FORM 30. Certificate of Service

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UNITED STATES COURT OF APPEALS
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CERTIFICATE OF SERVICE

Case Number 21-2249, 21-2315

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